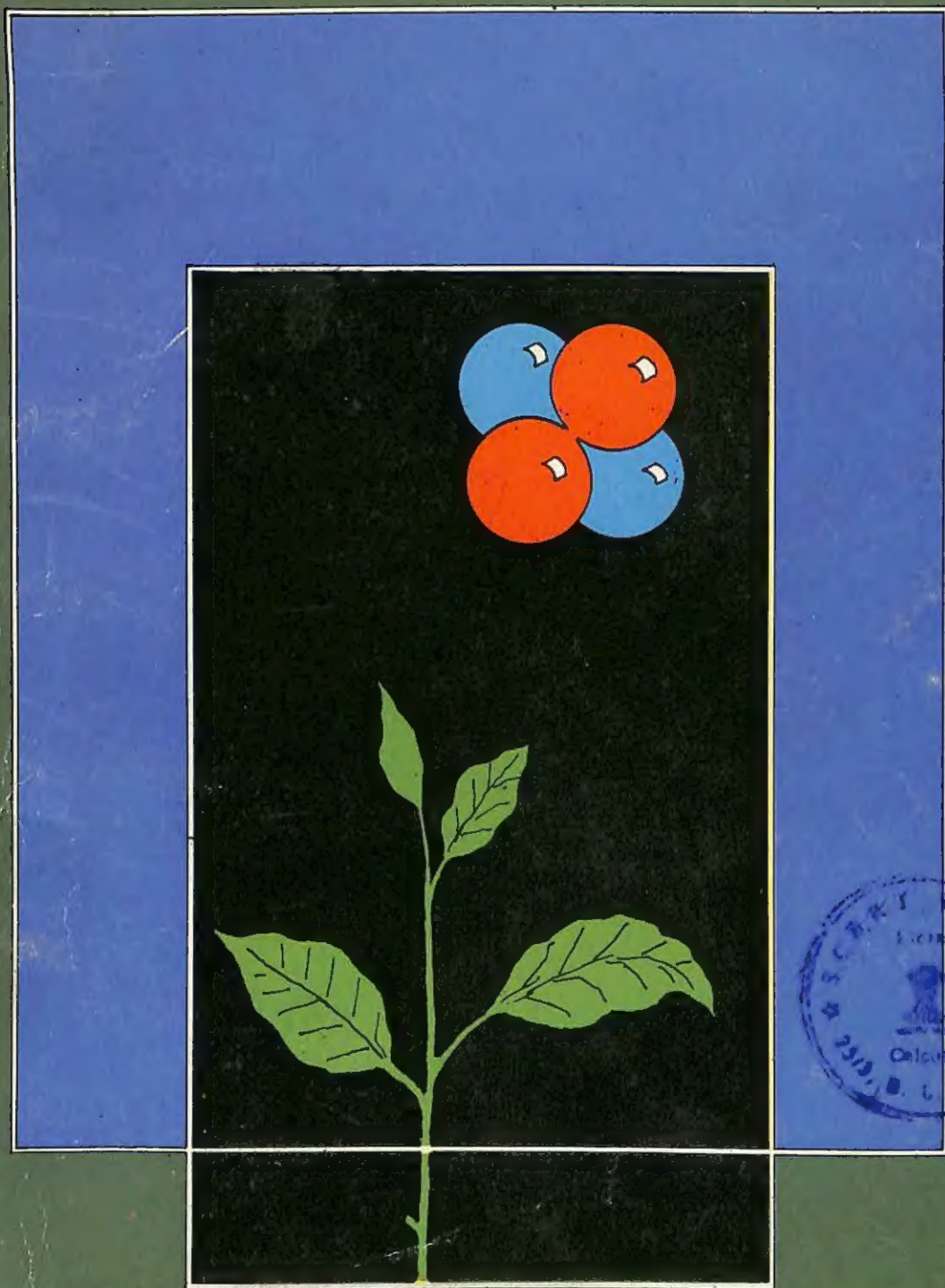


# SCIENCE

*A Textbook for Class VII*



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A TEXTBOOK FOR CLASS VII



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# SCIENCE

## A TEXTBOOK FOR CLASS VII



राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्  
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## Foreword

THE PRESENT TEXTBOOK of Science for Class VII is the continuation of the programme to develop instructional package on the lines of NPE (1986) and the general objectives communicated in the National Curriculum for Primary and Secondary Education: a Framework (Revised, 1987). The contents and the activities included in the book have been organized to inculcate knowledge, skills and attitudes on the basis of the specific objectives spelt out in the guidelines and the syllabus developed earlier.

The first draft of this book was developed by a writing team under the chairmanship of Dr. D. Balasubramanian, Deputy Director, Centre for Cellular and Molecular Biology, Hyderabad. The draft was reviewed in a national workshop in which classroom teachers, method masters and authors participated. The manuscript was modified in the light of the suggestions received. An editing team, under the guidance of the chairman of the writing team, finalized the manuscript. It is hoped that more comments and suggestions will be available for the improvement of the book.

I take this opportunity to thank Prof. C.N.R. Rao, F.R.S., who, as Chairman of the Advisory Board for the Development of Science and Mathematics books, took active interest and constantly inspired the writing team. Dr. D. Balasubramanian of CCMB, Hyderabad, as Chairman of the Writing Team, has done commendable work. I thank him and all the members of the writing team of this book for their sincere hard work. I acknowledge the contribution of all the reviewers and writers and thank the institutions they belong to for making it possible to prepare the book within a short time. My special thanks are due to Prof. P.M. Bhargava, Director, Centre for Cellular and Molecular Biology, Hyderabad, and his colleagues for offering excellent facilities for the development of this book. Thanks are also due to Prof. B. Ganguly, Head, Department of Education in Science and Mathematics, for his keen interest in and active guidance for the development of the book.

P.L. MALHOTRA  
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National Council of  
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## To Our Young Readers

WE HOPE that you enjoyed learning and doing science with the help of the book *Science* in Class VI. In this book, too, we provide you with many activities, examples and explanations that will make you understand, think and enquire. You might not be able to do all the activities, but try to do as many as you can. Doing experiments and analysing their results is an important part of science.

We have also tried to give you several connections between what you read in science textbooks and what you observe around you in nature. Many of the processes you see in nature are not classifiable as chemistry alone, or only physics or purely biological. They are at once all of these. When the polar bear hibernates in the Arctic winter, its action is biological. During this act, it must be surely thankful for the stored fat and its properties! For the physical property of the fat—that fat is a bad conductor of heat—which aids the bear in keeping warm; for the chemical property of the fat—its lower oxygen content makes it an energy-rich fuel, better than carbohydrates; and for the biology of being able to make and store the fat in its tissues. See how chemistry, physics and biology are integrated. This is the main reason why this book is on science, and not just on physics, or on chemistry or on biology.

You will find many items in boxes in many chapters. These boxes offer additional and interesting information. You do not need to memorize them—or anything in this book. The thing to do is to study the book and understand the principles. Once you understand a principle, you can tackle several problems easily.

We have been helped by many people, young and old, in writing this book. We have enjoyed writing this and we hope you will enjoy reading this. If you have any questions, do write to any of us and we will reply.

Best Wishes!

D. BALASUBRAMANIAN



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## States of Matter

WE SEE A VARIETY of objects around us. Some of these objects like stones, wood, copper and sugar are in a solid form, while some others like water, oil and milk are in a liquid form. There are also gases like oxygen, air and water vapour. Why is stone a solid, water a liquid, and air a gas? We know that water can exist in all the three forms—solid ice, liquid water and gaseous steam. Do all objects share this property? To begin with, let us try to understand the basic differences in these three states of matter.

### 1.1 Solids and Liquids Have Surfaces, but Gases Do Not

You will notice that a liquid or a solid has a surface. For example, water in a glass tumbler has the top surface open. Gases do not have such a surface. A simple experiment will show this difference.

#### *Activity 1*

Take two rubber balloons. Fill one of them with water. Inflate the other by blowing air into it. See that both the balloons are of approximately the same size. Tie up the balloons and hang them from a stand. Now take a sharp needle or pin and prick the balloons gently near

the neck. The balloon filled with air deflates completely and collapses while the one filled with water retains much of the water. You can also see the open surface of water in the balloon.

We all know that liquids need a container to hold them. Otherwise liquids tend to flow. Liquids cannot be heaped like solids. You can get a heap of stones, but you cannot get a heap of milk. It is possible to understand these properties if we remember that all matter is made up of tiny particles called *molecules*, and understand some properties of molecules. Molecules are constantly moving about. The higher the temperature, the greater is this motion.

Also, when two molecules come close they tend to stick together, because there is a weak force of attraction between them. What we see is the total effect due to both these factors. In a gas, the molecules are moving about very fast. They overcome the molecular forces of attraction and fly away in all directions. That is why a gas keeps expanding until it fills all the available space.

In a liquid, the molecular motions are not great enough to overcome the force

of attraction between molecules. That is why the molecules tend to stay together and give a condensed form. However, these forces are not strong enough to prevent the liquid from flowing. In a solid, the intermolecular forces are so strong that molecules cannot slip away. They are kept together in order and not allowed to move much. Now you can easily see why solids melt on heating and liquids turn into gases when heated. Also, when a gas is cooled, its molecules slow down and eventually condense into a liquid.

The earth has a blanket of air called the atmosphere, surrounding it. This blanket protects us from extreme cold or heat. The temperatures on earth range from  $-50^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ . The pressure of the atmosphere is 760 mm of mercury at the sea level. These two factors decide whether a given substance would be in a solid, liquid or gaseous form. That water is a liquid in most places on earth is due to these conditions. On the planet Jupiter, water will not be a liquid but exist only as ice. And it will boil off violently if placed on Mars or on the sunny side of Mercury. Also, oxygen and nitrogen are gases on earth. These substances would be liquids on Jupiter.

Our description of solids, liquids and gases above implies that all solids are very different from all liquids. Do you know of solids that flow (very slowly, of course!)? Have you seen a heap of tar on the roadside? Tar can be heaped, which means that it is a solid. However, if you observe that heap for a couple of days, you will notice that it is slowly flowing. The following experiment will show how some substances flow swiftly, while some others are very sluggish.

### *Activity 2*

Take a pipette of 10 ml volume. Suck in water beyond the top mark. Close the top of the pipette with your index finger. Release the finger gently and adjust the liquid level to the mark. Now release the finger and note the time needed for the water to flow out. Repeat the experiment using a thick oil like castor oil or machine oil, or gum. Note the difference in time (you may use a watch with a seconds hand or simply count numbers). If you like this experiment you may repeat it using as many liquids as you like and grade them according to their flow.

That solids can also exhibit a flow has interesting consequences. Mountains exert considerable pressure on the rocks below them and make them flow like tar in the tar heap. The continents on earth are now known to move slowly. Some scientists have proposed

that all the continents were together several million years ago. They have drifted apart slowly over these millions of years. You may like to take a map of the world and see how the continents fit together. The fossil records found in the continents lend support to this idea.

Take a piece of sponge. Is it a solid, a liquid or a gas? It is not spreading everywhere, nor does it need a container. It has a shape. Hence it must be called *solid*. Is this sponge compressible? Just by squeezing it, you will see that it can be compressed easily. How is that? Let us do an activity.

#### Activity 3

Take a large piece of sponge and lower it quickly in a bucket of water and squeeze it. You will see a large number of bubbles coming out. Later if you take the piece of sponge out of the bucket and squeeze it again, you will find water coming out. Where was the air or the water hidden in the sponge?

The sponge had many holes or pores in which air was trapped. When you squeezed it under water, the air in these pores was pushed out. You can also squeeze a wet sponge and force the water out of the pores.

The sponge is a very good example of a *porous* material. Other materials can also be porous to different extents. Soil is

porous and holds air and water in its pores. This property of soil is very useful for plants. A granite stone, on the other hand, has almost no pores. Do you think the clothes you wear, and paper on which your book is printed are porous materials?

### 1.2. Movement of Molecules

#### Activity 4

Make a concentrated solution of potassium permanganate by dissolving one tea spoonful of it in 100 ml of water. Let the solution stand in a beaker. Now tilt the beaker slightly and add 100 ml of clean water. Make sure that the water just slides along the beaker and does not disturb the permanganate solution. For some time you will see two layers distinctly. However, you can also see water diffusing into the coloured solution and also the opposite. After some time the two layers are not seen distinctly separate. Mark the time needed for the two layers to mix.

Light a candle in one corner of your classroom. You may now stand in some other corner and ask a friend of yours to light a few *agarbattis* using the candle flame. Very soon you will smell *agarbattis*. Note the time between his lighting the *agarbattis* and your smelling the fragrance.

In general, the molecules of a gas diffuse faster than the molecules of a liquid.

## TEACHER DEMONSTRATION

### *Diffusion in the Gas Phase*

Take a dry glass tube about 1 metre long. Insert at one end a plug of cotton wool soaked in concentrated ammonium hydroxide solution. And insert at the other end a plug of cotton wool soaked in concentrated hydrochloric acid. Now close both the ends of the glass tube with rubber corks, as shown in Figure 1.1. Within minutes you can notice a white deposit on the walls of the tube around the centre. Molecules of ammonia and hydrogen chloride coming out of the two plugs at the two ends diffuse towards the centre and when the two gases meet they react to form ammonium chloride. It is important that the tube be very dry, as otherwise the ammonium chloride will pick up the moisture and not form the white deposit on the walls.

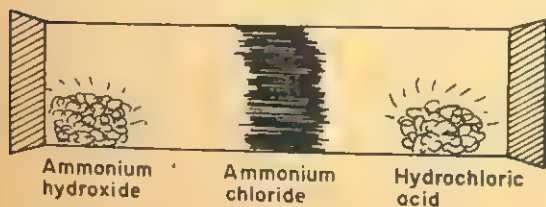


Fig. 1.1 *Diffusion of the gases ammonia and hydrogen chloride towards each other. When they meet near the centre, they react to produce ammonium chloride which is deposited as a solid coating the glass surface inside.*

In the experiments we conducted, smoke from the *agarbatti* diffused into the air in the room (gas to gas), and the

coloured solution and water diffused into each other (liquid to liquid). Note that molecules of water or of permanganate solution could not diffuse into the glass walls and come out! In general, gas to gas or gas to liquid or liquid to liquid diffusions are observed easily.

Do solids diffuse? It would not be correct to say that solids do not diffuse at all. However, the process is extremely slow. Often geologists find that several materials have diffused into a rock. Their guess is that the rock and the minerals must have melted first and then the diffusion could have occurred.

### *Activity 5*

Let us see an example of a liquid diffusing into a solid. Using an ink dropper, put a drop of ink on the centre of a clean blotting paper. You will find the liquid spreading out by diffusing into the blotting paper. If you observe carefully, you may also notice that the water in the ink diffuses faster than the colour of the ink.

There is another property related to the distances and the forces between the molecules in matter. This is seen whilst compressing a gas, a liquid and a solid. A bicycle pump compresses air into a small volume. You cannot compress a liquid or a solid much by putting pressure on them.

In general, the distance between molecules is smallest in a solid, a little more in a liquid and very large in a gas. Do you know why swimmers and divers

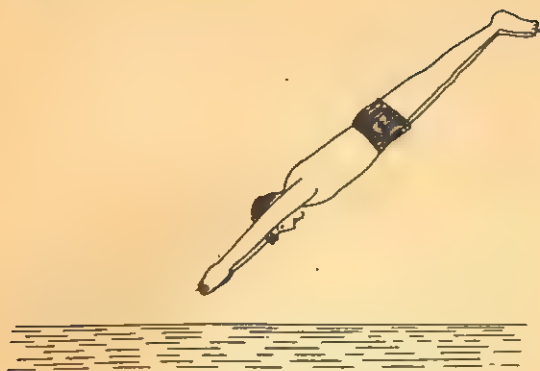


Fig. 1.2 Streamline action of a diver

take on a particular style when they dive into the water? Look at Figure 1.2. With this posture, the diver's body cuts through the water surface in one straight line. The water will be cut across and not hurt the diver. On the other hand, if the diver were to dive flat and expose more of his body to the water surface, he will be hurt. Hay or sand is put on the ground where a pole vaulter or a high jumper falls after the jump.

### YOU NOW KNOW

- Solids have definite shape and volume. Liquids have definite volume but not definite shape. Gases have neither, and thus have no surface.
- Attraction between the molecules in a solid holds them together. This attraction is weaker in a liquid. Intermolecular attraction is weakest in gases. Thus, molecules in the gas state dart about and gases expand to fill all the volume available.

- Diffusion is fastest in the gaseous state and slowest in solids.
- Gases are easily compressed while liquids and solids are not.
- Molecules are closely spaced in a solid. Hence a solid is not easily compressed. The distance between neighbouring molecules is a little longer in a liquid and longest in a gas. Hence a gas is highly compressible.

### NOW ANSWER THESE

1. Generally, gases can be compressed very easily, but solids and liquids are almost incompressible. How, then, do you explain the ease with which a sponge, made of solid material, can be compressed?
2. Why do solids and liquids have an open surface while gases do not?
3. Explain why solids have a definite shape and liquids do not.
4. When liquid bromine is placed in the bottom of a glass tumbler, brown fumes of bromine from this liquid slowly move up in the tumbler until the whole tumbler is filled with brown gas.
  - (i) Explain why this occurs even though bromine is denser than air.
  - (ii) How would you expect the bromine to diffuse if the glass tumbler containing bromine liquid is put in another big glass tumbler containing hot water?

5. What are the two factors which decide whether a given substance would be in a solid, liquid or gaseous state?
6. Fill in the blanks:
- (i) In gases, the force of attraction between molecules is \_\_\_\_\_.
- (ii) The space between the molecules is largest in \_\_\_\_\_ and smallest in \_\_\_\_\_.
7. Why is hay or sand put on the ground where a high jumper falls after the jump?

## Elements, Compounds and Mixtures

THINGS AROUND YOU are of endless variety. They are all made of matter—for example—air, water, rocks, minerals, plants, animals, the earth and the other planets and galaxies. Even you are made of matter. But what is matter made of? What is it about one kind of matter that makes it different from another kind? We will try to answer some of these questions in this chapter.

### 2.1 Matter as Molecules and Atoms

We know that matter can be classified into elements, compounds and mixtures. These in turn are made of small particles such as molecules and atoms.

#### ELEMENTS

When a substance is made of only one kind of atoms, it is called an *element*. For example, copper wire is made of the atoms of only copper. Copper is thus called an element. Gold, silver and iron are other examples of elements. Similarly, the gaseous element oxygen is made of oxygen molecules, and each oxygen molecule is made of two oxygen atoms. Hydrogen, nitrogen, chlorine are other examples:

#### COMPOUNDS

When two or more elements combine together, they produce *compounds*. Compounds can be broken down into the elements from which they are made. Water is an example of a compound. It is made of water molecules. Each water molecule is made of two atoms of hydrogen and one atom of oxygen. Thus, if we analyse water, we will find two types of atoms, those of hydrogen and oxygen. Sugar is yet another example of a compound. A molecule of sugar is made of 12 atoms of carbon, 22 atoms of hydrogen and 11 atoms of oxygen. Carbon dioxide is formed by burning the element carbon in the presence of the element oxygen. Each molecule of the compound carbon dioxide consists of one atom of carbon and two atoms of oxygen. Remember that the properties of a compound are different from the properties of its constituent elements. Hydrogen burns, oxygen supports burning and both are gases; but water is a liquid and it puts off fire.

Another property of a compound is that it contains the elements in a fixed

proportion. No matter how and where sugar is produced, it will contain carbon, hydrogen and oxygen in the same proportion of 12:22:11. Similarly any sample of pure water will contain hydrogen and oxygen in the same proportion of 2:1.

### MIXTURES

Many substances we come across in daily life are not pure elements or compounds, instead they are mixtures. A mixture could contain several elements and compounds. Air is a mixture of several gases. It contains elements such as nitrogen, oxygen and compounds such as carbon dioxide and water vapour. It also contains some other gases and dust particles. Mixtures could be of several types as shown in the Table 2.1.

TABLE 2.1

Mixture-type	Examples
1. Gas in gas	Air
2. Gas in liquid	Aerated water (soda): oxygen and carbon dioxide dissolved in water
3. Liquid in liquid	Lemon juice and water, water and alcohol
4. Solid in liquid	Sea water, sugar solution
5. Solid in solid	Mixture of spices, soil, alloys of metals

Iron and sulphur are elements. Mixing of these elements in powdered form in any ratio gives their mixture. But when their mixture in a definite ratio is strongly heated, a new substance known as iron sulphide is formed. Upon heating, the two elements iron and sulphur chemically react to produce the compound iron sulphide. Iron sulphide does not have any properties of iron and sulphur. On the other hand, the mixture of iron and sulphur has all the properties of their constituents—iron and sulphur.

Notice the difference between elements, compounds and mixtures shown in Fig. 2.1.

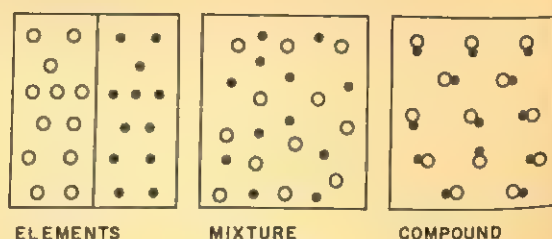


Fig. 2.1 Black balls represent one element and the white ones another. In the middle panel they are simply mixed but in the right panel they have combined to make a compound.

You may wonder about how one would find out whether a given substance is an element or a mixture or a compound. It is not an easy task. Water, known to man for millions of years, was thought to be an element. It was only 200 years ago that the English scientist Cavendish proved that water is a

compound. He prepared water by burning hydrogen gas in air. Further proof came when water was broken down (decomposed) into the elements hydrogen and oxygen, using electricity. Similarly, the substance lime (the chemical name is calcium oxide) was thought to be an element. Sir Humphry Davy showed in 1808 that lime is made up of the elements calcium and oxygen. The element oxygen itself was not known until 1774 when Priestley obtained it from mercury oxide. It could not be further broken down into any other element.

It is quite easy and interesting to prepare the element oxygen and study it. Here is an activity to prepare oxygen.

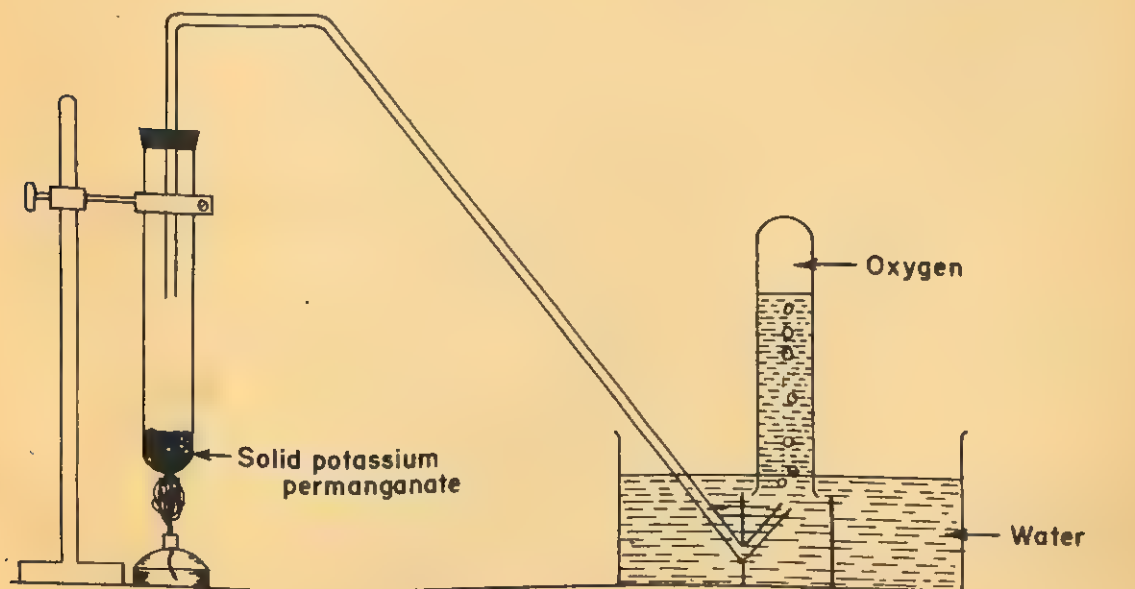
### Activity 1

Take one teaspoonful of solid potassium permanganate in a boiling tube fitted

There are two ways of showing that a substance is a compound. One way is to decompose it into its elements. The other is to make the substance (to synthesize) from its constituent elements. That water is a compound (and not an element) was shown by using both the methods. Lavoisier, the French chemist who studied the element oxygen and gave it its name, showed that mercury oxide is a compound. He first synthesized it from the elements mercury and oxygen, then he also decomposed it into its elements.

with a cork and a delivery tube as shown in Figure 2.2.

Fig. 2.2 *Preparing oxygen gas by decomposing potassium permanganate*



Fill a boiling tube or a bottle with water, and invert it in a trough containing water holding your palm on the mouth of the tube. Make sure that no air bubbles enter while you invert the tube. Heat the permanganate using a spirit lamp. To begin with, air from the boiling tube will be driven out. Later oxygen gas will start coming out. So, after you start heating allow some bubbles to escape in the trough. Then insert the delivery tube inside the tube as shown in Figure 2.2. When the tube is filled with oxygen you can remove it from the trough. Keep a lid on the mouth of the tube to prevent oxygen from escaping. Test the gas by lowering a glowing *agarbatti* in it. The flame will brighten in oxygen.

### Activity 2

Is sugar an element or a compound? Take a teaspoonful of sugar in a boiling tube. Heat it gently on the flame as shown in the Figure 2.3.

As you warm the sugar, it turns brown. Later it begins to char, that is, it looks blackish. Also observe the top of the test tube. You will find small droplets of water on the inside of the tube. Where did this water come from? If we were cooling the tube, we could have said that it was moisture condensing. But we are warming the tube. The water must have come from the dry sugar! What is left behind in the boiling tube is charcoal or carbon. You can scoop out some of it and see if it burns like coal.

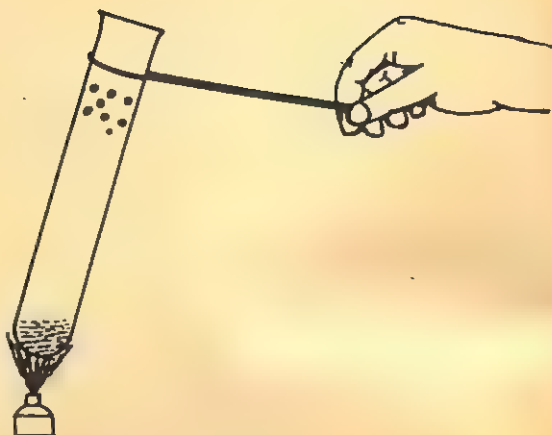


Fig. 2.3 Gentle heating of solid sugar decomposes it and releases water that condenses on top.

Sugar, decomposes upon heating and gives carbon and water. Hence sugar cannot be an element. Since water is made of hydrogen and oxygen, we conclude that sugar is a compound made up of carbon, hydrogen and oxygen.

### ANSWER THESE

1. Fill in the blanks.
  - (i) An element is made of only one kind of \_\_\_\_\_.
  - (ii) A molecule of nitrogen consists of \_\_\_\_\_ atoms of the element nitrogen.
  - (iii) A compound is formed by the combination of at least \_\_\_\_\_ elements.
2. Give two examples of each of the following mixture types:
  - (i) Solid in liquid
  - (ii) Liquid in liquid
  - (iii) Gas in liquid

## 2.2 Symbols and Formulae

By now more than 100 chemical elements are known. It is out of these elements that all matter in the whole universe is made. These elements include metals like zinc, copper, silver, gold, iron, sodium, potassium and others, and non-metals like carbon, silicon, oxygen, hydrogen, sulphur, nitrogen and iodine. Most of these elements occur on earth in various amounts. Ninety per cent by mass of the earth's crust is composed of only five elements—oxygen, silicon, aluminium, iron and calcium.

Figure 2.4 shows the percentage composition by weight of the elements in the earth's crust.

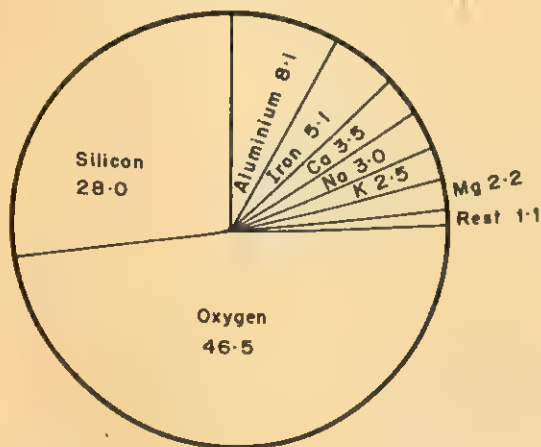


Fig. 2.4. Diagram showing the composition of the elements on the earth's crust

When we want to refer to these elements and their many compounds, it would be very inconvenient to use their full names all the time. It would be more

convenient to give each of them an abbreviation, or a symbol. There are many examples where abbreviations are used in daily life. For example, in the phrase "700 B.C.", the abbreviation "B.C." means "Before Christ". You know that a stenographer writes a lot of words quickly in a small notebook by using the symbols of a script known as *shorthand*. In the same way, scientists use symbols and group of symbols as chemical shorthand to represent elements, compounds and chemical reactions conveniently and accurately. Each element is symbolised by a single letter or two letters of the English alphabet. In most cases, the first letter of the name of an element is taken as symbol and written in capitals. For example, H stands for hydrogen, S for sulphur, O for oxygen and C for carbon.

In some cases, two or more elements have names beginning with the same letter. In order to avoid confusion, one more letter from its name is added to the symbol. For example, Cl is used for chlorine, Ca for calcium, Co for cobalt, Cr for chromium, Al for aluminium and so on. In such symbols, only the first letter is written in capital. Symbols of some elements have been derived from their latin names. Examples of some such elements are given in Table 2.2, and the symbols of many common elements are given in Table 2.3.

The practice of using symbols for chemicals was started centuries ago by alchemists, who were the predecessors

TABLE 2.2

Element	Latin Name	Symbol
Sodium	Natrium	Na
Copper	Cuprum	Cu
Iron	Ferrum	Fe
Potassium	Kalium	K
Silver	Argentum	Ag
Tin	Stannum	Sn
Gold	Aurum	Au
Mercury	Hydrargyrum	Hg
Lead	Plumbum	Pb

of chemists. Many alchemists surrounded their knowledge with secrecy and magic, and used mysterious symbols as shown in Figure 2.5.











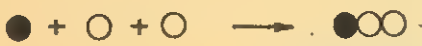
A symbol is not merely used as a sign of a chemical element. It also denotes one atom of that element as well as the mass of an atom. Thus, the symbol for

TABLE 2.3  
Symbols of Some Common Elements

Element	Symbol	Element	Symbol
Hydrogen	H	Phosphorus	P
Helium	He	Sulphur	S
Boron	B	Chlorine	Cl
Carbon	C	Argon	Ar
Nitrogen	N	Potassium	K
Oxygen	O	Calcium	Ca
Fluorine	F	Cobalt	Co
Neon	Ne	Iron	Fe
Sodium	Na	Copper	Cu
Magnesium	Mg	Zinc	Zn
Aluminium	Al	Silver	Ag
Silicon	Si	Tin	Sn
Bromine	Br	Lead	Pb
Gold	Au	Mercury	Hg
Iodine	I	Uranium	U

hydrogen, H represents or stands for one atom of the chemical substance called hydrogen. H also stands for the mass of one atom of hydrogen. H does *not*

Fig. 2.5 Symbols used by alchemists and by Dalton to represent elements

ALCHEMIST'S SYMBOLS	
 COMMON SALT	 GOLD
 SILVER	 LEAD
	 TIN
DALTON'S SYMBOLS	
 SILVER	 LEAD
	 GOLD
 CARBON	 OXYGEN
	
CARBON DIOXIDE	

John Dalton, who gave us the theory that all matter is made of atoms, simplified the symbols. Some of his symbols are also shown in the same figure. It was J.J. Berzelius from Sweden who proposed that the first letter in the name of an element be used as its symbol. At that time, many scientists disliked and opposed this suggestion strongly! It took almost 100 years for this idea to be accepted and used by all.

symbolise the molecule of hydrogen, because the molecule of hydrogen has 2 atoms of hydrogen and H means one atom only of this element.

How then can we symbolise the molecules of an element or of a compound? We denote them by the group of atomic symbols. This grouping is known as the chemical formula of the molecule.

We know that some elements such as helium exist as single atoms, while others such as oxygen exist in groups of two or more atoms called molecules. The number of atoms in a single molecule of an element is known as *atomicity*.

Carbon (C), sodium (Na), copper (Cu), aluminium (Al), iron (Fe), exist as collection of atoms. Such elements are represented by the symbol of their atoms. In the case of a molecule of an element, the number of atoms constituting the molecule (atomicity) is written as a subscript after the symbol of that element. For example, a molecule of oxygen is represented as  $O_2$ . It shows that it contains two atoms of oxygen in combination. The formulae of molecules of some common elements are given in Table 2.4.

The molecule of a compound consists of the atoms of the constituting elements in a definite proportion. That is, the composition of a compound is fixed. The atoms are present in a molecule of a compound in whole numbers. For example, one atom of hydrogen and one atom of chlorine make one molecule of

TABLE 2.4

Molecules of some common Elements

<i>Element</i>	<i>Formula</i>	<i>Atomicity</i>
Hydrogen	$H_2$	2
Helium	He	1
Oxygen	$O_2$	2
Sulphur	$S_8$	8
Phosphorus	$P_4$	4
Nitrogen	$N_2$	2
Bromine	$Br_2$	2
Chlorine	$Cl_2$	2

hydrogen chloride. Thus, a molecule of hydrogen chloride can be represented as  $H_1Cl_1$  or HCl. That is, the number of atoms present in a molecule of a compound is represented as a subscript written after the symbol of that particular element (usually the subscript 1 is not written, since it is obvious). Similarly, two atoms of hydrogen and one atom of oxygen make one molecule of water. A molecule of water is represented by the formula  $H_2O_1$  or  $H_2O$ . The molecule ammonium chloride is made of one atom of nitrogen, four atoms of hydrogen and one atom of chlorine. It is, therefore, represented by the formula  $N_1H_4Cl_1$  or  $NH_4Cl$ .

Thus, if we know the number of atoms of the elements constituting a molecule of a compound we can write its chemical formula or the molecular formula. Table 2.5 gives some examples:

To represent a certain number of atoms or molecules of a given element or a compound, the appropriate numeral is

TABLE 2.5

## Formulae of Some Common Compounds

<i>Compound</i>	<i>Formula</i>	<i>Constituting Elements</i>	<i>Number of Atoms of each Element combining together to form one Molecule of the Compound</i>
1. Carbon dioxide	CO <sub>2</sub>	Carbon (C)	1
		Oxygen (O)	2
2. Sulphuric acid	H <sub>2</sub> SO <sub>4</sub>	Hydrogen (H)	2
		Sulphur (S)	1
		Oxygen (O)	4
3. Sugar	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	Carbon (C)	12
		Hydrogen (H)	22
		Oxygen (O)	11
4. Potassium permanganate	KMnO <sub>4</sub>	Potassium (K)	1
		Manganese (Mn)	1
		Oxygen (O)	4
5. Ammonia	NH <sub>3</sub>	Nitrogen (N)	1
		Hydrogen (H)	3
6. Nitric acid	HNO <sub>3</sub>	Hydrogen (H)	1
		Nitrogen (N)	1
		Oxygen (O)	3
7. Phosphorus pentoxide	P <sub>2</sub> O <sub>5</sub>	Phosphorus (P)	2
		Oxygen (O)	5
8. Mercuric chloride	HgCl <sub>2</sub>	Mercury (Hg)	1
		Chlorine (Cl)	2
9. Aluminium bromide	AlBr <sub>3</sub>	Aluminium (Al)	1
		Bromine (Br)	3
10. Borax	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	Sodium (Na)	2
		Boron (B)	4
		Oxygen (O)	7

written before its molecular formula. For example, 2 HCl denotes two molecules of hydrogen chloride, 2 Na means two atoms of sodium, 2O<sub>2</sub> means two molecules of oxygen, 4 P<sub>2</sub>O<sub>5</sub> means four molecules of phosphorus pentoxide.

The formula HCl of hydrogen chloride stands for

- the elements from which it is constituted,
- the proportion of hydrogen and chlorine atoms in one molecule of

- hydrogen chloride,  
 (iii) one molecule of hydrogen chloride,  
 and  
 (iv) the mass of one molecule of  
 hydrogen chloride.

## ANSWER THESE

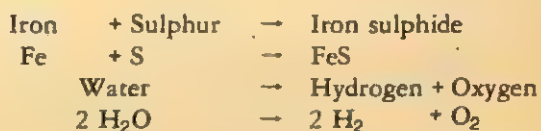
1. He is the symbol of helium. What all does it represent about helium?
2. Write down the chemical symbols of the following elements:  
 Potassium, Calcium, Phosphorus, Nitrogen and Sulphur
3. Write down the formulae for compounds in the following cases:
  - (i) A molecule of zinc sulphate consists of one atom of zinc, one atom of sulphur and four atoms of oxygen.
  - (ii) A molecule of hydrogen peroxide consists of two atoms of hydrogen and two atoms of oxygen.
  - (iii) One atom of calcium and one atom of oxygen form one molecule of calcium oxide.
4. What does  $3 \text{Na}_2\text{B}_4\text{O}_7$  represent?
5. Can you write the names of several elements having the same initial letter? Write their symbols.

## 2.3 Chemical Reactions and Equations

When iron (Fe) and sulphur (S) are heated, they combine to form a new substance called *iron sulphide*, FeS. When electric current is passed through water, water breaks down to produce

hydrogen  $\text{H}_2$  and oxygen  $\text{O}_2$ . These are examples of chemical reactions and are represented by chemical equations.

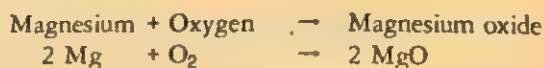
Substances taking part in a chemical reaction are called *reactants*. The reactants are placed on the left side of the chemical equation. The chemicals formed in a reaction are known as *products*. The products are represented on the right side of the equation. For example, the above two chemical reactions are written as



The chemical equation is *balanced* so that the total number of atoms of each element is identical on both sides. The balancing of an equation represents the fact that atoms are neither created nor destroyed during a chemical reaction. They are only rearranged.

The following are some other chemical reactions with their equations:

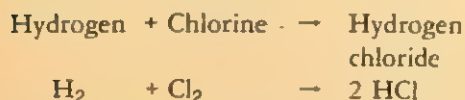
- (i) When magnesium is burnt in air or oxygen, magnesium oxide is formed.



The equation shows that two atoms of magnesium combine with one molecule of oxygen and form two molecules of magnesium oxide.

- (ii) The combination of one molecule of hydrogen with one molecule of chlorine to form 2 molecules of

hydrogen chloride is written as:



Thus, a chemical equation is a short and simple representation of a chemical reaction. An equation for a chemical reaction can be written if the formulae of reactants and products are known.

#### ANSWER THESE

1. Potassium permanganate has one atom each of potassium and manganese and 4 atoms of oxygen. Write down its chemical formula.
2. What is a balanced chemical equation?
3. What are reactants and products in a chemical reaction?
4. Write a balanced chemical equation for the following reactions:
  - (i) One molecule of nitrogen combines with three molecules of hydrogen to form two molecules of ammonia.
  - (ii) One atom of carbon reacts with one molecule of oxygen to form one molecule of carbon dioxide.
5. Write the following reactions in the form of chemical equations.
  - (i) Two atoms of zinc + one molecule of oxygen  $\rightarrow$  Two molecules of zinc oxide
  - (ii) 4 atoms of sodium + 1 molecule of oxygen  $\rightarrow$  2 molecules of sodium oxide.

#### YOU NOW KNOW

- Matter may be classified into elements, compounds and mixtures.
- An element is composed of atoms of the same kind.
- A compound is made by the combination of two or more elements in a definite proportion.
- A mixture is formed by mixing two or more substances in any ratio.
- A molecule of an element consists of the atoms of the same kind.
- A molecule of a compound is made of atoms of different kinds.
- An element is represented by a symbol.
- A chemical formula is a group of symbols representing the different elements constituting a compound.
- The chemical formula of a compound stands for one molecule of a compound, the proportion of various atoms present in it, and the mass of one of its molecules.
- A chemical equation is a symbolic representation of a chemical reaction.
- In a chemical equation, the reactants are written in the left hand side and the products on the right hand side.
- In a balanced chemical equation, the total number of atoms of each element on the left hand side is equal to the number on the right hand side.

#### NOW ANSWER THESE

1. What is a compound? How does it differ from a mixture?

2. Name the three most abundant elements on the earth's crust.
3. (i) Name two compounds and write their chemical formulae.  
(ii) Write the names and symbols of the elements they are composed of.
4. (i) Write the symbols of the elements: calcium, helium, potassium and nitrogen.  
(ii) Write the names of the elements having the following symbols: C, Br, P, Al, Si
5. The formulae of potassium dichromate and sodium sulphate are  $K_2Cr_2O_7$  and  $Na_2SO_4$  respectively.  
(i) Name the elements constituting these compounds.  
(ii) Write the number of atoms of each constituting element present in one molecule of these compounds.
6. State whether the following statements are true or false. Also correct the false statements.  
(i) An element is made of atoms of different kinds while a compound is composed of atoms of the same kind.  
(ii) In a compound, the atoms of constituting elements combine in any ratio.  
(iii) The molecules of an element are made of same kind of atoms.
- (iv) The most abundant element in the earth's crust is aluminium.  
(v) The smallest particle of a compound is an atom which possesses all its properties.  
(vi) A chemical equation represents the chemical formula of a compound.
7. Match the following:
- | A                             | B      |
|-------------------------------|--------|
| (i) A molecule of an element  | N      |
| (ii) A molecule of a compound | Na     |
| (iii) An atom of a metal      | $N_2$  |
| (iv) An atom of a non-metal   | $NH_3$ |
8. Which one of the following is a compound?  
(i) A black solid residue left when sugar is heated  
(ii) Nitrogen gas  
(iii) Air  
(iv) Carbon dioxide
9. Write the following chemical reactions in word forms as well as in chemical equations.  
(i) When one atom of zinc reacts with one molecule of sulphuric acid, one molecule of zinc sulphate and one molecule of hydrogen are formed.  
(ii) When one molecule of hydrogen and one molecule of iodine

combine together, two molecules of hydrogen iodide are formed.

- (iii) Two molecules of mercury oxide are heated to form two atoms of mercury and one

molecule of oxygen.

- (iv) When two atoms of magnesium react with one molecule of oxygen, two molecules of magnesium oxide are formed.

## CHAPTER THREE

### Acids, Bases and Salts

YOU HAVE ALREADY LEARNT that a large number of compounds can be made by the combination of various elements. More than three million compounds are already known. These compounds can be classified in several ways on the basis of colour, taste, state, solubility and magnetic properties. Some of the common fruits such as lemon, raw-mango, tamarind are sour in taste because of the presence of acids in them. On the other hand, the solution of some substances like lime (chuna), soap, washing soda are soapy in touch and bitter in taste. These substances contain bases or alkalies. When an acid and a base react, a new compound called *salt* is formed. In this chapter, we will learn about acids, bases and salts and their properties and uses.

Most of the elements can be burnt in oxygen or in air to form compounds known as *oxides*. An oxide is thus a compound of an element with oxygen. Water is an oxide of hydrogen. Carbon dioxide,  $\text{CO}_2$  is the oxide of carbon. You might have seen the brown rust on iron nails and iron screws. This rust is actually an oxide of iron. It is formed on the iron surface in the presence of moist air which contains oxygen.

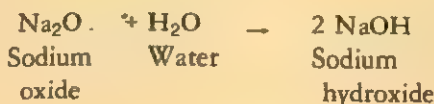
#### Activity 1

A strip of magnesium wire or a ribbon is needed here. Hold the piece of wire or the ribbon with a pair of tongs over a flame. What do you see? The metal burns with a dazzling flame. *Caution* Do not look at the flame for too long! Collect the white ash formed on a piece of paper. The ash is magnesium oxide.



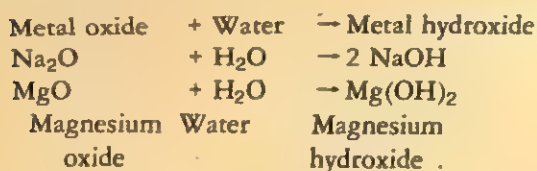
#### TEACHER DEMONSTRATION

Cut a piece of sodium metal with a knife. Dry it on the folds of a filter paper. Take the piece of the dry sodium metal in a long-handled spoon and heat it over the flame. Sodium burns in oxygen of the air and forms a white powder. This white powder is sodium oxide. Dissolve a little of this powder in 10 ml of water. Does it dissolve? Sodium oxide dissolves in water and forms sodium hydroxide.



Similarly other metals like zinc, calcium and copper also burn in air to form metallic oxides.

Several of these oxides easily dissolve in water. Upon so doing, they form *hydroxides*. These hydroxides are called *bases* commonly known as *alkalies* (The term alkali means ash and refers to the metal oxide).



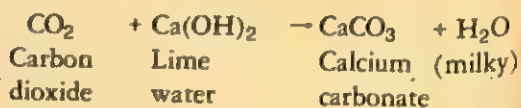
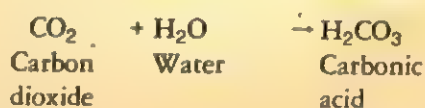
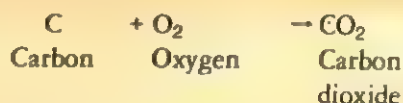
These hydroxides are soapy to touch. They easily react with acids and neutralise them. A convenient test to find out whether a solution is acidic or basic is to check for colour change in a litmus paper. When a drop of acid is put on blue litmus paper, it turns red. And a drop of base or alkali turns red litmus blue.

### Activity 2

Place a piece of charcoal on a long handled spoon or hold it with a pair of tongs. Heat it red hot over the flame and introduce it into a wide mouth bottle. Carbon combines with the oxygen in air and forms its oxide— $\text{CO}_2$ . Take out the spoon from the bottle and add a little water in the bottle and shake. Divide the solution of the gas in water into two parts. To one part, add lime water. What do you observe? You will see that the lime water changes milky. Dip a glass rod in the second part. Touch the rod on

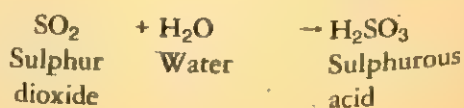
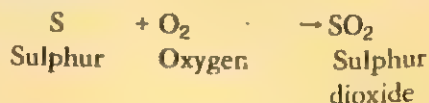
a strip of red litmus and blue litmus papers. What change in colour of the litmus papers do you observe?

You will notice that the blue litmus changes to red. There is no change in the colour of red litmus. It shows the acidic character of the solution. That is, carbon dioxide shows the acidic property.



### Activity 3

Burn a little powder of sulphur in a long handled spoon. As it starts burning, introduce the spoon in a wide mouth bottle. After the sulphur has burnt, take the spoon out of the bottle. Add a little water in the bottle, cork the bottle and shake it to dissolve the gas. Dip a glass rod in the solution and test it with strips of blue litmus and red litmus papers. What change in colour do you observe? You will see that blue litmus changes to red. It shows the acidic nature of the solution.



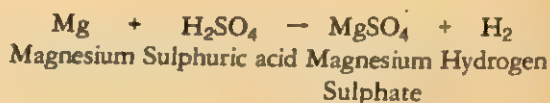
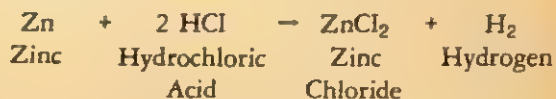
Non-metals such as carbon, sulphur and phosphorus burn in oxygen and form oxides. These oxides are *acidic oxides*.

### 3.2 Properties of Acids and Bases

We have seen that the oxides of metals react with water to produce hydroxides. These hydroxides turn red litmus blue in colour, react with carbon dioxide  $\text{CO}_2$  to produce carbonates and react with acids. On the other hand, oxides of non-metals such as carbon C, nitrogen N, phosphorus P or sulphur S produce acids upon reacting with water. They turn blue litmus red, react with bases and with metals. Table 3.1. lists oxides, acids and bases.

One important property of acids is that they react with metals to produce

salts and release hydrogen gas. For example:



Hydrochloric acid  $\text{HCl}$ , nitric acid  $\text{HNO}_3$  or sulphuric acid  $\text{H}_2\text{SO}_4$  are not the only acids we study. In everyday life we come across many acids. Vinegar used in the kitchen is a solution of an acid called acetic acid and has the formula  $\text{C}_2\text{H}_4\text{O}_2$ . Lemon juice contains citric acid

TABLE 3.1

#### Some Oxides, Acids and Bases

Element	Oxide	Upon reacting with Water
<i>Non-metals</i>		<i>Acids</i>
Carbon, C	Carbon dioxide, $\text{CO}_2$	Carbonic acid, $\text{H}_2\text{CO}_3$
Sulphur, S	Sulphur dioxide, $\text{SO}_2$	Sulphurous acid, $\text{H}_2\text{SO}_3$
	Sulphur trioxide, $\text{SO}_3$	Sulphuric acid, $\text{H}_2\text{SO}_4$
Phosphorus, P	Phosphorous pentoxide, $\text{P}_2\text{O}_5$	Phosphoric acid, $\text{H}_3\text{PO}_4$
Nitrogen, N	Nitrogen pentoxide, $\text{N}_2\text{O}_5$	Nitric acid, $\text{HNO}_3$
<i>Metals</i>		<i>Bases</i>
Sodium, Na	Sodium oxide, $\text{Na}_2\text{O}$	Sodium hydroxide, $\text{NaOH}$
Potassium, K	Potassium oxide, $\text{K}_2\text{O}$	Potassium hydroxide, $\text{KOH}$
Calcium, Ca	Calcium oxide, $\text{CaO}$	Calcium hydroxide, $\text{Ca(OH)}_2$
	(quick lime)	(lime water)
Magnesium, Mg	Magnesium oxide, $\text{MgO}$	Magnesium hydroxide $\text{Mg(OH)}_2$
	(magnesia)	(milk of magnesia)

in it. Unripe fruits like raw mangoes, or raw grapes and tamarind (imli) taste sour, just as vinegar and orange juice do. In fact, the very name acid means sour in the Latin language.

You might have seen copper and brass vessels are coated with tin or *kalai*, that makes them shine like silver. This *kalai* needs to be done often if the vessel is used to cook food with tamarind (imli) or lemon juice. What do you think happens then? The acids in these juices react with the copper and corrode it. The *kalai* layer protects the vessel from the acid action for a while. Of course, the best would be to use a metal that does not easily react with these acids to make kitchen vessels.

What about bases or alkalies in everyday life? The word alkali is from the Arabic language, meaning the ashes (which reacted with acids). Baking soda is an alkali used in the kitchen and is called sodium bicarbonate. Washing soda is sodium carbonate  $\text{Na}_2\text{CO}_3$ . Caustic soda and caustic potash are sodium hydroxide  $\text{NaOH}$  and potassium hydroxide  $\text{KOH}$ . *Choona* or quicklime is calcium oxide  $\text{CaO}$  while lime water is calcium hydroxide  $\text{Ca(OH)}_2$ . These hydroxides of calcium  $\text{Ca}$ , sodium  $\text{Na}$ , potassium  $\text{K}$  and similar metals are

called *alkalies*. The general name of this class of compounds is *bases*.

A frequent complaint that we have is what is called acidity in the stomach. You might be interested to know that our stomach contains a solution of hydrochloric acid which helps in digesting the food we eat. When the amount of this acid becomes low, we have digestion problems. Often, however, the acid content becomes higher than normal. This might be because of eating too spicy and hot food or even because of psychological worries and tension. When this happens the walls of the stomach become sore or damaged, leading to stomach ulcers. The treatment for this often involves reducing the acidity by taking tablets or solutions of milk of magnesia, which is magnesium hydroxide  $\text{Mg(OH)}_2$ , or aluminium hydroxide  $\text{Al(OH)}_3$  and similar compounds. Now you know why these tablets are called *antacids*.

#### ANSWER THESE

1. Name three acids and three bases used in the laboratory. Write their formulae.
2. Fill in the blanks
  - (i) Acetic acid is present in \_\_\_\_\_

while \_\_\_\_\_ is present in lemon.

- (ii) Carbon burns in air to form \_\_\_\_\_. It is \_\_\_\_\_ oxide. Its aqueous solution turns \_\_\_\_\_ litmus to \_\_\_\_\_.
  - (iii) The gas which escapes out from many aerated soft drinks is \_\_\_\_\_.
  - (iv) An aqueous solution of sodium oxide changes \_\_\_\_\_ litmus to \_\_\_\_\_.
  - (v) The chemical formula of lime water is \_\_\_\_\_.
3. Write equations for the action of water on:
- (i) Magnesium oxide
  - (ii) Sulphur dioxide
  - (iii) Calcium oxide.
- Also mention in each case whether the resulting compound is an acid or a base.
4. You are given hydrochloric acid solution, sodium hydroxide solution and water in three different bottles. How would you check which bottle has which compound?

### 3.3 Reactions of Alkalies with Acids

You have learnt that acids and alkalies have chemically different properties. What will happen when they are mixed? Let us do this activity.

#### Activity 4

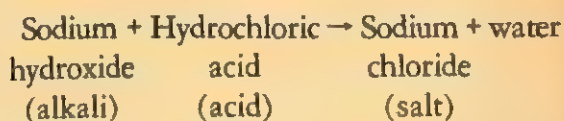
Take 10 ml of dilute caustic soda NaOH solution in a 50 ml beaker (or a

glass tumbler). Add 2 to 3 drops of the indicator (phenolphthalein solution) to the beaker. This is an indicator just as litmus is, and gives a pink colour with solutions of alkali but is colourless in acid solution. What change do you observe in the solution of caustic soda? It becomes pink in colour. Add dilute hydrochloric acid using a dropper and stir the mixture with a glass rod. Stop the addition of acid when the pink colour just disappears.

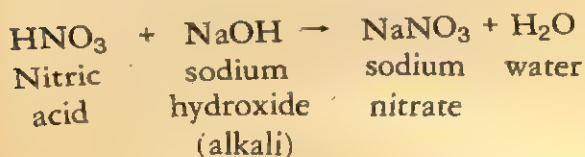
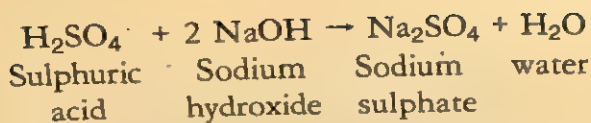
Now add carefully one more drop of the caustic soda solution and again a drop of acid solution. What change do you observe?

Thus, when the solution is alkaline, it is pink, while it is colourless in acid solution. The effect of adding the acid is to destroy the alkaline property of caustic soda. On the other hand, addition of caustic soda solution destroys the acidic properties of hydrochloric acid solution. In this way, they appear to cancel the effect of each other. Finally, when the right quantity of acid is added to alkali solution, the resulting solution becomes *neutral*, that is, neither acidic nor basic in nature. This process of cancelling an alkali with an acid or vice versa is called *neutralisation*.

The neutralisation reaction is:



Similar activities can be performed with other acid and alkali solutions.



*Salts are obtained from neutralisation reactions of acids and alkalies.*

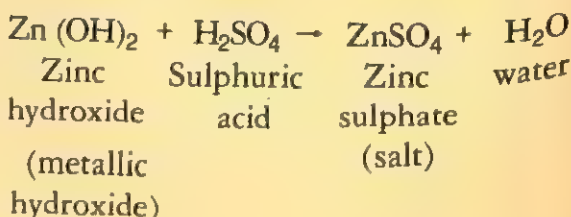
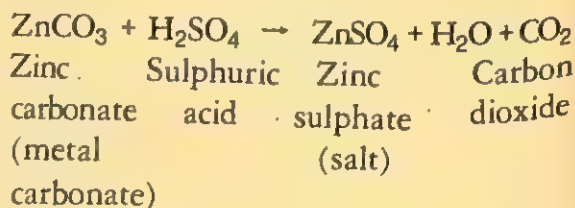
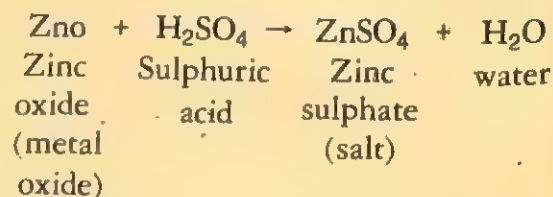
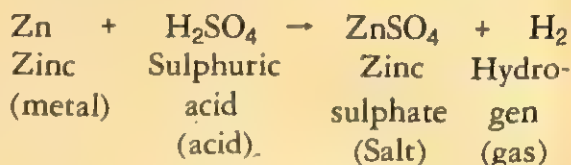
The word 'salt' here is a general term. It does not refer only to common salt or table salt which is sodium chloride NaCl. Here salt refers to the compound formed by the neutralisation of an acid by a base.

#### ANSWER THESE

- Write the chemical equation for the neutralisation of caustic potash (potassium hydroxide) by sulphuric acid. Name the salt formed in the reaction.
- Write down the formula and the name of the salt formed in each of the following neutralisation reactions:
  - $\text{H}_2\text{SO}_4 + 2 \text{NaOH} \rightarrow \text{_____} + \text{H}_2\text{O}$
  - $\text{H}_2\text{CO}_3 + 2 \text{NaOH} \rightarrow \text{_____} + \text{H}_2\text{O}$
  - $\text{HNO}_3 + \text{NaOH} \rightarrow \text{_____} + \text{H}_2\text{O}$
- Mention some of the salts which you come across in daily life.
- Which salt is formed when carbon dioxide  $\text{CO}_2$  is passed in lime water? Write down the chemical equation for the reaction.

#### 3.4 Salts

Salts are also formed by reacting acids with metals, metal oxides or metal carbonates. In fact, carbonates themselves are salts of carbonic acid. It is a case of making one salt from another. When we turn lime water,  $\text{Ca(OH)}_2$  milky with carbon dioxide,  $\text{CO}_2$ , we are making the salt calcium carbonate,  $\text{CaCO}_3$ . Here, Calcium hydroxide,  $\text{Ca(OH)}_2$  is an alkali. The acid is carbonic acid which is formed by dissolving  $\text{CO}_2$  in water. Similarly, zinc oxide  $\text{ZnO}$ , zinc carbonate,  $\text{ZnCO}_3$  or zinc hydroxide  $\text{Zn(OH)}_2$  with dilute sulphuric acid give the salt zinc sulphate,  $\text{ZnSO}_4$ .



Many salts come into our daily use. Common salt ( $\text{NaCl}$ ) is essential to our diet. It is also used as a preservative in pickles and in curing meat and fish. In industry, it is used for the manufacture of chlorine, hydrochloric acid, washing soda, sodium hydroxide and many other compounds.

Washing soda (sodium carbonate),  $\text{Na}_2\text{CO}_3$ , is used in laundry. It is the starting material for the preparation of a number of other compounds such as glass, caustic soda, and detergent powders.

- Sodium bicarbonate,  $\text{NaHCO}_3$ , is used as baking powder. It is used in medicines to neutralise the acidity in the stomach. It is also used in fire extinguishers.
- Potassium nitrate,  $\text{KNO}_3$  is used in the manufacture of gun powder, in making fire works, as fertilizer and in the glass industry.
- Copper sulphate  $\text{CuSO}_4$ , is used as fungicide and in electroplating, dyeing and calico printing.
- Potash alum (*phitkari*)  $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24 \text{H}_2\text{O}$ , is used in the purification of water. It is obtained by crystallisation from a solution containing potassium sulphate,  $\text{K}_2\text{SO}_4$  and aluminium sulphate,  $\text{Al}_2(\text{SO}_4)_3$  in a proportion of 1:2 (approximate).
- Soaps are also sodium salts of certain acids. They are used in cleaning and laundry, textile industry, sanitation, food processing, synthetic rubber, paints and paper.

## TEACHER DEMONSTRATION

### *Preparation of Soap from Oil*

Take 10 ml of cottonseed oil (linseed, soyabean, neem, mahua or olive oil can also be used) in a beaker or a vessel. Add to it 10 ml of 40% sodium hydroxide solution. Heat this mixture in a water bath and go on stirring till a thick paste is obtained.

Fats and oils are made up of fatty acids and glycerine. When boiled with alkali, the oil reacts with the alkali to form the salt of the fatty acid. This salt is the soap.

Oil + Alkali (sodium hydroxide) → Soap + Glycerine

To separate soap from the mixture, a small amount of water is added to dissolve the soap. A teaspoonful of powdered common salt is added. The soap floats on the surface and is removed. This process is called *salting out*. The soap is then dried and cut into bars and cakes.

The seas are great sources of salts. One litre of sea water has about 35 grams of salts. Sodium Chloride,  $\text{NaCl}$  is the main salt present there. Much of the salt that we use in our lives is obtained from the sea. In coastal areas, seawater is trapped in shallow beds and evaporated in the sunlight. The white solid crystals of salt are then processed, packed and sent to markets.

Our body needs a variety of salts, largely chlorides, iodides, sulphates, bicarbonates and phosphates of calcium,

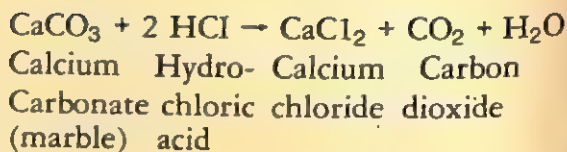
iron, magnesium, sodium and potassium. When we sweat, we lose some of these salts. This is why sweat is salty. When we lose too much of water from the body, we get dehydrated (that is, to lose water) and lose salt too. This is particularly so after heavy exercise or in cases of dysentery and diarrhoea. When this happens, we should drink a lot of water containing salts (and sugar) to bring back the salt levels in the body to normal. This is called oral rehydration. Such oral rehydration actually saves children from dying of dysentery and diarrhoea.

We will learn in the chapter on water about hard and soft water. Water becomes *hard* due to the presence of dissolved calcium and magnesium salts in it. Hard water has some undesirable qualities and this needs to be *softened*.

#### A PROJECT: *Preparation of Carbon Dioxide and a Study of Its Properties*

Fix a test tube or a flask on a stand and place some marble chips in it. Marble is calcium carbonate,  $\text{CaCO}_3$ . Close the open end of the vessel with a rubber cork fitted with a delivery tube as shown in Figure 3.1.

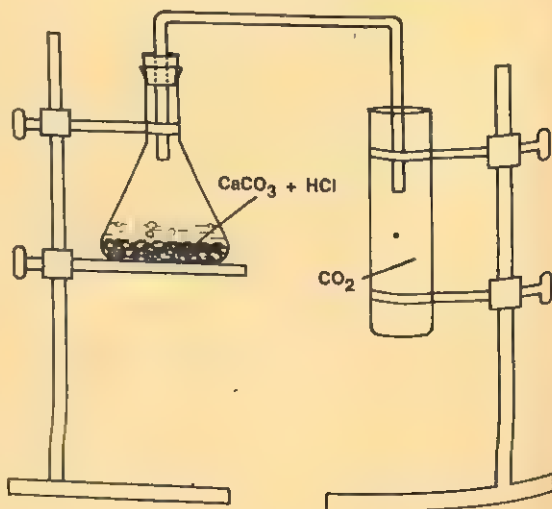
Pour 5 ml of dilute hydrochloric acid into the vessel and close the vessel. Gas will start forming now. This gas can be collected in a jar as shown. Let us collect sufficient amount of this gas and test its properties. The reaction that has happened is:



Carbon dioxide is a gas that we use daily one way or the other. Let us study some of its properties.

- (i) Smell the gas in the jar. Any smell? None. Does it have any colour? None.  $\text{CO}_2$  is a colourless gas with no smell.
- (ii) Take a burning matchstick or splinter and introduce it inside the jar. What happens? The fire is put off (extinguished). Carbon dioxide has this property of putting off fires. This is used in fire extinguishers that you see in cinema theatres, railway stations and public buildings.

Fig. 3.1 Collecting carbon dioxide from the reaction between  $\text{CaCO}_3$  and  $\text{HCl}$



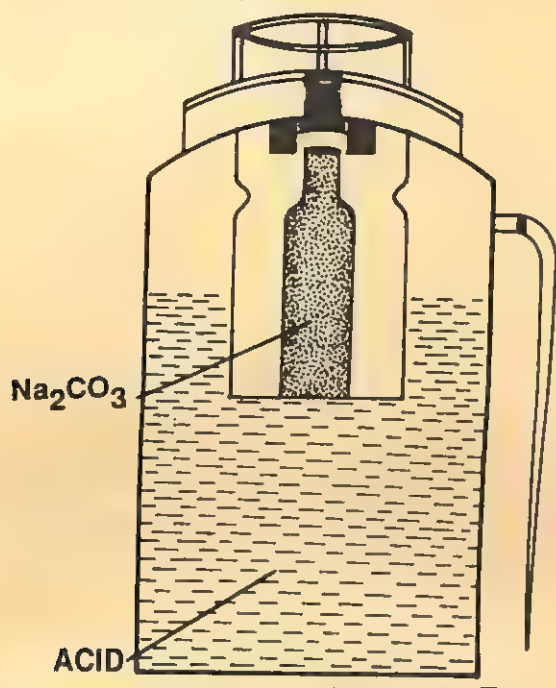


Fig. 3.2 The Portable Fire Extinguisher that releases  $\text{CO}_2$  gas. The outer chamber has sodium carbonate and the inner chamber has acid.

The common fire extinguisher shown in Figure 3.2, is a metal cylinder with a tube and a nozzle. Inside it has a solution of sodium carbonate in the outer chamber. In an inner chamber, sulphuric acid is kept. When the extinguisher cylinder is inverted and the stopper opened by pushing the plunger, the acid will react with the sodium carbonate to produce  $\text{CO}_2$ . The  $\text{CO}_2$  gas can be sent through the side tube nozzle and directed at the fire to extinguish it.

(iii) Recall how we collected the  $\text{CO}_2$

gas—like one collects a liquid. The gas displaced air upward from the jar! This is because  $\text{CO}_2$  is heavier or denser than air. This also means that we can pour  $\text{CO}_2$  gas much as we pour liquids. You can do this by taking another gas jar that has air in it. Invert our  $\text{CO}_2$  containing jar over the other air-filled jar. After some time, test the gas inside the lower jar with a burning match. Fire is put out, showing that  $\text{CO}_2$  has been poured into the new jar. It displaced the air upward and settled down in the jar.

Carbon dioxide has the tendency to settle down as a gas layer near the ground, and we can see this near open *sigrees* or coal stoves in camps or in villages. Along with the smoke and the dust that settles near the ground, the burnt product of coal,  $\text{CO}_2$ , also settles, making further burning difficult. The fire needs to be often fanned to sustain. Fanning removes the ash on top of the coal and also removes the nearby  $\text{CO}_2$  and brings fresh air for burning.

(iv) Is  $\text{CO}_2$  able to dissolve in water? In order to find out, invert the  $\text{CO}_2$  gas jar on a trough of water as shown in Figure 3.3.

Check the level of water first and after a little while. If the gas dissolves, the water level would change (go up). You will find that  $\text{CO}_2$  does dissolve a little in water. You can check the solution of  $\text{CO}_2$

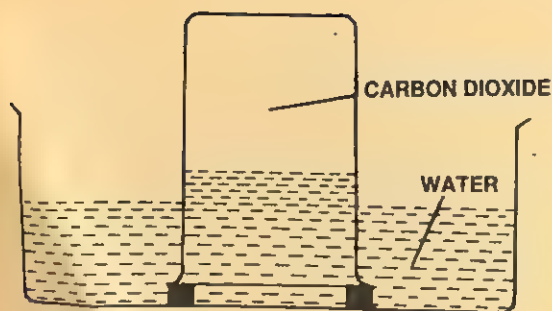
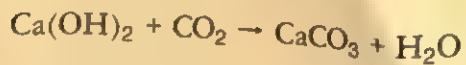


Fig. 3.3  $\text{CO}_2$  dissolves a little in water.

in water to see if it is basic, acidic or neither. Does it turn blue litmus red? Yes, it does. So the solution is an acid and the acid is called *carbonic acid*. Many soft drinks and soda actually have  $\text{CO}_2$  in them. The  $\text{CO}_2$  escapes when the bottle is opened and the "fizz" of escaping gas from the solution is due to  $\text{CO}_2$ .

- (v) Because  $\text{CO}_2$  is an acidic oxide, it should be able to react with metal hydroxides. The famous reaction of  $\text{CO}_2$  turning lime water milky is just this:



Take a little bit of lime water (calcium hydroxide) and shake it in the  $\text{CO}_2$  jar. The lime water turns milky white. Why milky? Because white coloured chalk or  $\text{CaCO}_3$  is formed in the reaction. It is not very soluble in water and stays as a suspension, milky in appearance.

### YOU NOW KNOW

- Most of the elements, upon burning in oxygen, form oxides.
- Metals form metallic oxides or basic oxides.
- Non-metals form non-metallic oxides or acidic oxides.
- Many acids have sour taste.
- Acid solutions in water turn blue litmus red.
- Many metals react with acids and produce hydrogen.
- Alkalies have bitter taste and are soapy to touch.
- Alkali solution in water turns red litmus blue.
- When an acid reacts with a base, a salt is formed.
- Salts can also be prepared by the reaction of many acids with metals, metal oxides and metal carbonates.

### NOW ANSWER THESE

1. Fill in the blanks
  - (i) Neutralisation is the reaction between an acid and a \_\_\_\_\_ to form \_\_\_\_\_ and \_\_\_\_\_
  - (ii) The solution formed by reacting  $\text{P}_2\text{O}_5$  with  $\text{H}_2\text{O}$  turns \_\_\_\_\_ litmus to \_\_\_\_\_
  - (iii) \_\_\_\_\_ reacts with lime water to produce \_\_\_\_\_ which is milky in appearance because it is \_\_\_\_\_ in water.
2. Write 'T' against a true statement and 'F' against a false one. Also, correct the false statements.

## ACIDS, BASES AND SALTS

- (i) Ammonia, dissolved in water, shows acidic properties.
- (ii) Orange juice turns blue litmus red.
- (iii) Copper does not react with tamarind (imli) water.
- (iv) Alum (phitkari) acts as an antacid.
3. What will you do if some acid is spilt on the table?
4. Match the substances on the left side with the appropriate properties on the right side.
- |                       |                                  |
|-----------------------|----------------------------------|
| (a) Vinegar           | (i) changes red litmus blue      |
| (b) Sodium chloride   | (ii) is sour to taste            |
| (c) Milk of magnesia  | (iii) Major salt of the sea      |
| (d) Potassium nitrate | (iv) used in fertilizer industry |
5. How would you prepare:
- crystals of copper sulphate from metallic copper.
  - calcium chloride from marble (calcium carbonate).
6. Substance 'A' was obtained by reacting washing soda with vinegar. What is A? And what is its formula?

## Heat

ENERGY IS THE ABILITY to do work. When an object has the ability to do work, we say that the object has energy. In this chapter we shall study a form of energy called *heat energy*. Heat has the ability to do work. The steam engine pulls a train by converting heat into mechanical energy.

Heat can also be converted to other forms of energy. For example when charcoal is heated, it emits light. Here heat produces light. In a hot air balloon the hot gases, being lighter than the surrounding air, rise and are made to lift weights. Here heat is used to produce mechanical energy. The heat in a fire cracker produces both sound and light.

Other forms of energy can also be converted to heat energy. For example you can feel the heat produced from the mechanical energy by rubbing your palms vigorously against each other. When a candle burns in air, chemical energy is converted into heat. In an electric bulb, electrical energy is converted into light and heat.

### 4.1 Effects of Heat

When an object is heated, many changes take place. Obviously, the object becomes

hotter! There are some less obvious changes too. The object may expand in size on heating. A substance may change its state when heated. For example ice changes into water on heating. Heat can also speed up chemical reactions. Heat can even kill! In fact we boil milk and drinking water in order to kill harmful bacteria. The gentle and sustained warmth that the hen gives when it sits on its egg produces a chicken!

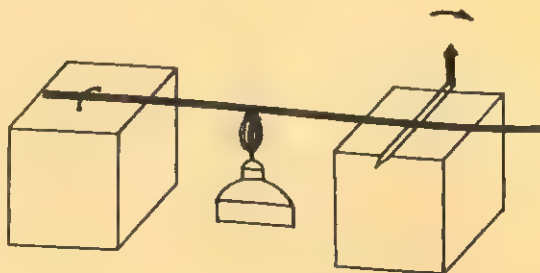
### EXPANSION

Most substances expand on heating and contract on cooling. Let us perform some experiments to study this property.

#### Activity 1

Take two blocks of wood and place an iron or tin rod on them. Fix the rod

Fig. 4.1 Showing the thermal expansion of a solid

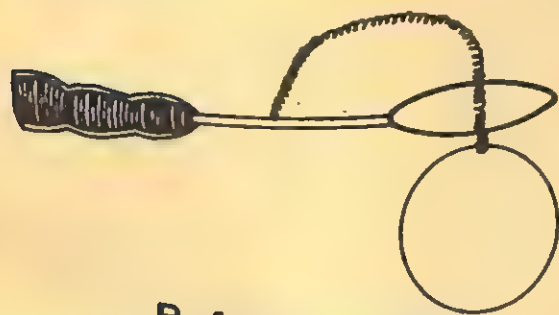


firmly on one side. Insert a pencil under the other end of the rod. Make a pointer and stick it to the edge of the pencil (Figure 4.1). Place a spirit lamp under the rod and heat the rod. What happens to the pencil and the pointer?

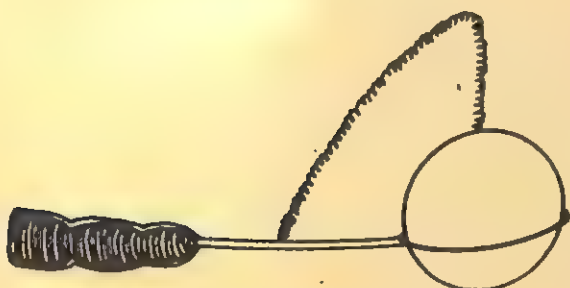
### Activity 2

You can do this activity if you have a ring and ball apparatus shown in Figure 4.2. The ring in this apparatus has just the right diameter to let the ball pass through. Now heat the ball and see if it passes through the ring.

Fig. 4.2 Upon heating, the ball expands in size and can no longer go through the ring.



Before heating



After heating

### Activity 3

Take a test tube and fill it to the brim with water. Take a rubber stopper with a hole in the centre. Insert a hollow glass tube in this hole and fix the stopper to the tube so that a little liquid rises in the tube. See Figure 4.3(a). Now heat the test tube over a flame. Observe the level of liquid in the thin tube. Now stop the heating and let the test tube cool down. Observe what happens to the level of the liquid.

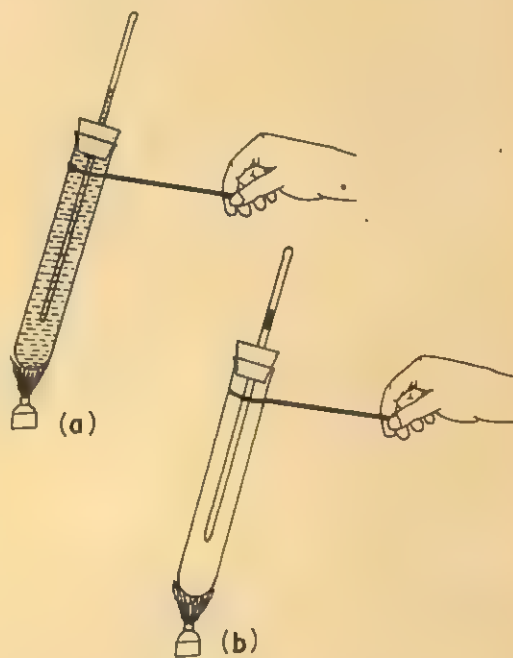


Fig. 4.3 (a) Expansion of a liquid on heating  
(b) Expansion of a gas on heating

### Activity 4

Take an empty test tube and fit it with the stopper prepared in Activity 3. Drop a little coloured solution in the thin tube [Fig. 4.3. (b)]. Now heat the arrangement

over a candle. Observe the height of the coloured drop. Stop the flame and watch the drop.

These activities show that most of the substances in any state, liquid, solid, or gas expand when heated and contract when cooled. Liquids expand more than solids and gases expand the most. In fact gases expand even when very little heat is supplied to them. If you hold the arrangement of Activity 4 in your palms tightly you will immediately see the coloured drop rising. Even the heat of your palm is enough to expand the air inside the tube.

Such expansion on heating is frequently used to make some tasks easier. When an iron rim is to be fitted on a wooden wheel of a bullock cart, the ironsmith always heats the rim first. This expands the rim so that it slips easily on the wheel. As the rim cools it contracts to its correct size and fits tightly in the wheel.

#### ANSWER THESE

1. Sometimes we have to warm the neck of a bottle whose lid is screwed tightly. Once we do that we can unscrew the lid easily. Why?
2. How will you remove the iron ball after it has dropped into the ring in Fig. 4.2?
3. Why does a *poori* swell-up on frying?

### 4.2 Hotness and Temperature

The degree of hotness of an object is

called its *temperature*. We can compare the temperature of two objects and decide which is higher by using our sense of touch. But we do this only if their heat is bearable. It would be painful to touch and compare the temperatures of boiling water with that of boiled water cooled for three minutes. Even if their heat were bearable, touching them might not give a very reliable estimate of their temperatures. Similarly, we cannot rely on our sense of touch in order to measure the temperature of a sick man.

We can use the fact that substances expand on heating in order to measure temperature accurately. For example we can compare the temperatures of two substances by bringing them in contact with a metal rod. The substance that produces more expansion in the rod would have a higher temperature.

However, this method may not be practical. Solids expand so little that we might have to make another instrument to measure the expansion! It would be much more convenient to use liquids or gases. We have seen that the liquids and gases expand much more than solids on heating to the same extent. For example, we could use the test-tube in Activity 3 itself as a thermometer. The test tube in which the liquid rises to a greater height has the higher temperature.

#### ANSWER THESE

1. Usually thermometers use mercury as the fluid and not water. Which do

you think expands more on heating—mercury or water?

2. As soon as the test tube is removed from the source of heat, the level of liquid drops. How is this avoided in the thermometer that doctors use?

#### Some Common Temperatures (in degrees C)

Freshly prepared tea	→	80
Hot water for a usual bath	→	45
Temperature of ice cream	→	-5 to 5
Temperature at the surface of the sun	→	6000
Temperature of the bright side of the moon	→	100
Temperature of the dark side of the moon	→	-180
Temperature of the hottest place on earth (in Libya)	→	51
Temperature of the coldest place	→	-42
Temperature of ice, salt mixture	→	-20
Temperature of the human body	→	37

### 4.3 Amount of Heat

We can measure the amount of heat from the change in temperature that it produces. Let us see relation between the amount of heat and the temperatures it can produce in different substances.

#### Activity 5

Take two beakers. Fill one with 200 ml and the other with 400 ml of water from the same tap or source. They would then have the same temperature. Place one beaker on a tripod and heat it with a

spirit lamp for five minutes. Record the rise in temperature of the water. Now heat the water in the second beaker on the same flame and record the temperature.

Both the beakers receive the same amount of heat from the spirit lamp. Compare the change in temperature of the water in the two beakers. You will find that the rise in the temperature of 200 ml of water is twice the rise in the temperature of 400 ml of water.

We can, therefore, conclude that the rise in temperature depends on the amount of the water taken. This property helps us to define the unit for measuring the amount of heat. This unit is called the *calorie*.

*1 calorie is that amount of heat which can raise the temperature of 1 g of water by 1°C.*

This means that when 1 calorie of heat is supplied to 1 gram of water, its temperature will rise by 1°C. Sometimes we also use the kilocalorie to measure the amount of heat. One kilocalorie is equal to 1000 calories. That is, 1 kilocalorie can raise the temperature of 1 kilogram of water by 1°C. The energy content of food is measured in kilocalories (sometimes written as Calories, with a capital C).

The modern and generally accepted unit of heat energy is no longer calorie but the *joule*. The joule is accepted internationally and is abbreviated as J. *One calorie is equal to 4.184J.*

## HEAT CAPACITY

If we supply 1 calorie or 4.184J of heat to 1 gram of water, its temperature would rise by  $1^{\circ}\text{C}$ . What would be the rise in the temperature if the same amount of heat were supplied to 1 gram of vegetable oil or 1 gram of iron? Let us find out.

*Activity 6*

Take two beakers one with 200 grams of water and the other with 200 grams of vegetable oil at room temperature. Heat both the beakers with a spirit lamp for five minutes. Record the rise in temperature of each, using a thermometer. Be sure to stir the liquid so that the heating is uniform throughout. Compare the rise in the temperature of water with the rise in the temperature of oil. You will find that the temperature of oil rises much more than the water.

*The heat capacity of a substance is the amount of heat needed to raise the temperature of a substance by  $1^{\circ}\text{C}$ . The unit of heat capacity is joules per  $^{\circ}\text{C}$ . Since oil requires less amount of heat to raise its temperature by  $1^{\circ}\text{C}$  than same mass of water, the heat capacity of oil is less than that of water. In fact, water has the highest heat capacity compared to most other substances. The specific heat of a substance is the amount of heat required to raise the temperature of 1 kilogram of a substance by  $1^{\circ}\text{C}$ . The unit of specific heat is Joule/kg  $^{\circ}\text{C}$ . Table 4.1 is a chart of specific heats of some common substances.*

TABLE 4.1

## Specific Heats of Some Substances

	Joule/kg $^{\circ}\text{C}$
Water	4.18
Lead	0.1258
Copper	.3762
Zinc	.3762
Iron	.5298
Aluminium	.8778
Ice	2.2990
Vegetable oil	1.9646
Kerosene	2.1118
Alcohol	2.4044
Air	1.0032

## CHANGE OF STATE

*Activity 7*

Take about 200-300 g of ice in a 500 ml beaker. Immerse a thermometer in the ice so that its temperature can be recorded. Heat the ice from below and record the temperature as the ice melts. Did you notice that it stays at  $0^{\circ}\text{C}$  until the ice melts. Only when all the ice has melted, does its temperature start rising again. You can also take butter or solid wax instead of ice for this activity.

Substances exist in three forms or states—solid, liquid and gas. When a solid substance like ice or wax is heated, it melts and becomes liquid. This change of state occurs at a definite temperature. In the earlier activity you might have seen that ice melts at  $0^{\circ}\text{C}$  and that wax melts at about  $63^{\circ}\text{C}$ , butter melts at a temperature lower than that of wax.

Let us think about Activity 7. Why did the temperature stay at  $0^{\circ}\text{C}$  for quite a while, and begin increasing sharply once the ice melted? Remember that you were supplying heat to the ice, while it was melting. Yet there was no change in temperature. All the heat that was supplied was hidden or was *latent*. Once the ice melted, the heat supplied could be detected by the thermometer. The reason behind this latent heat absorption is given in Chapter 1 on the states of matter. Remember that molecules attract one another with weak forces of attraction called intermolecular force. This force holds them together in a *condensed* state as a solid or a liquid. The heat supplied to ice at  $0^{\circ}\text{C}$  is used up to weaken this intermolecular force but not to increase the temperature. The energy needed for this is called the latent heat. Once this energy is given, the molecules are free and form the liquid state. Again, at the boiling point, the intermolecular forces in the liquid will have to be broken so that gas is formed. That would be done by supplying the latent heat of vapourisation at the boiling point.

The temperature at which a substance changes its state from solid to liquid is called its *melting-point*. Given below in Table 4.2 are the melting points of some substances.

TABLE 4.2

## Melting-points of Some Solids

Water (ice)	$0^{\circ}\text{C}$
Iron	$1535^{\circ}\text{C}$
Copper	$1082^{\circ}\text{C}$
Zinc	$410^{\circ}\text{C}$
Naphthalene	$80^{\circ}\text{C}$

If you continue to heat water for a long time it will start boiling and change into steam. The temperature at which a substance changes its state from liquid to gas is called its *boiling point*.

TABLE 4.3

## The Boiling-points of Some Common Substances

Water	$100^{\circ}\text{C}$
Mercury	$357^{\circ}\text{C}$
Iron	$2750^{\circ}\text{C}$
Copper	$2310^{\circ}\text{C}$
Zinc	$907^{\circ}\text{C}$

## ANSWER THESE

1. What is meant by the heat capacity of a substance? In what units is it expressed?
2. If you supply the same amount of heat to 1 kg of copper and 1 kg of aluminium, which would have the higher temperature?

It is important that we know how much heat a burner supplies to a vessel placed on it, per unit time. This knowledge will enable us to supply the desired amount of heat to any substance. The method is very easy.

Take 500g of water in a beaker and measure its temperature with a thermometer. Let us call this temperature  $T_1$ . Heat this water on a stove for five minutes, stirring it so that the water is heated uniformly. Measure the temperature after five minutes. Let us call this temperature  $T_2$ . Remember that the specific heat of water is 4.18 joules/gram  $^{\circ}\text{C}$ . Therefore, the amount of heat received by the water is:

$$= \text{Specific heat} \times 500 \times (T_2 - T_1)$$

$$= 4.18 \times 500 (T_2 - T_1)$$

This heat was supplied in five minutes.

Therefore, the burner supplies:

$4.18 \times 500 (T_2 - T_1)/5$  joules in one minute. If you have measured  $T_1$  and  $T_2$  you can find the number of joules supplied by your burner per minute. The next time you want to supply, say, 2000 joules you can easily calculate how long

to heat it. But remember to use the same beaker and keep it at the same height. If you do not, your substance might not get the right amount of heat you want to supply!

## YOU NOW KNOW

- Heat is a form of energy.
- Substances expand on heating and contract on cooling.
- Solids expand the least and gases expand the most.
- A thermometer uses the expansion of liquids to measure temperature.
- One calorie is the heat required to raise the temperature of 1 gram of water by  $1^{\circ}\text{C}$ .
- The number of joules required to raise the temperature of a substance by  $1^{\circ}\text{C}$  is called its heat capacity.
- The joule is the standard unit of heat energy.  $4.18\text{J} = 1 \text{ calorie}$ .
- Specific heat of a substance is the amount of heat required to raise the temperature of 1 kilogram of a substance by  $1^{\circ}\text{C}$ .
- Water has the highest specific heat.
- Substances change their state from solid to liquid or from liquid to gas on heating.
- Changes of states take place at definite temperatures.
- The temperature at which a substance changes from the solid to the liquid state is called the melting-point.
- The temperature at which the substance changes from liquid to gas is called the boiling-point.

## NOW ANSWER THESE

1. If you have to choose a material to build a solar heater, which material would you choose?
2. If you have to build a water cooler, which material would you choose (you can look up in the table of specific heat)?
3. A glass of 200 ml of water is kept in sunlight for 10 minutes. Its temperature goes up by  $2^{\circ}\text{C}$ . How much heat from the sun reaches the glass in one minute?
4. How many joules of heat are needed to increase the temperature of 1 kg of copper by 50 degrees?

## Transfer of Heat

WE KNOW THAT WHEN hot objects are kept away from the source of heat, they cool down. For example, hot milk left in a cup cools down. This is because the hot milk gives part of its heat energy to the surrounding air and cools down. The surrounding air absorbs the heat from the hot milk and heats up. Of course, the increase in temperature of the air is so little that it can hardly be detected. But, if we dip a spoon into the milk we can quickly detect the rise in the temperature of the spoon.

Heat from a hot body is transferred to a cold body in three different ways. We shall study these in this chapter.

### 5.1 Conduction of Heat

#### Activity 1

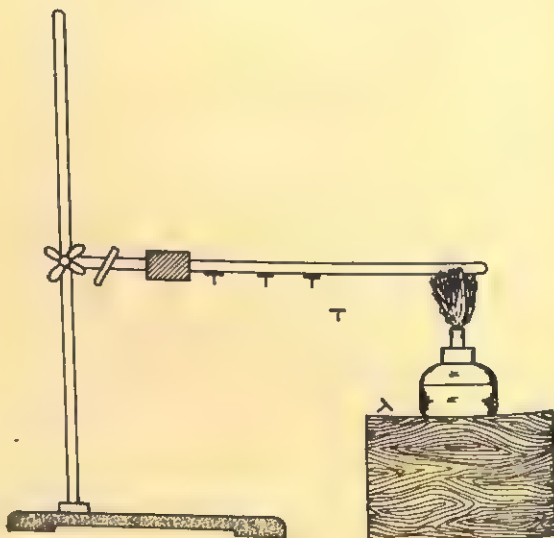
Fix some iron nails on a flat aluminium rod with wax. Clamp the rod to a stand as shown in Fig. 5.1. Heat the rod at one end with a spirit lamp. Note the order in which the nails begin to drop.

You would notice the nails placed closer to the heated end drop off first. The nails at the clamped end drop last. The part of the rod in contact with the

flame heats up first. The heat is *conducted* to the other parts of the rod.

We have learnt that in a solid the molecules are packed close together. When one end of the solid is heated, the molecules there absorb the heat energy and begin to vibrate rapidly. These molecules in turn, cause their neighbours to vibrate. This process continues along the rod and energy is transferred from the hotter part to the colder part. Such a transfer of energy between different

Fig. 5.1 Experiment to show the conduction of heat



parts of a body, or from one body to another in contact with it is called *conduction*.

Conduction from the hot part of an object to its colder parts, or from one hot object to a colder one occurs if the two parts are in contact. The conduction of heat stops once the two objects have the same temperature. We see this happen in a thermometer. When the bulb of the thermometer is brought in contact with the hot object, the mercury absorbs the heat and its level rises. Once the thermometer and the object are at the same temperature, no further heat is transferred, and the mercury level does not rise. Remember that there are two important conditions for heat to be conducted from one object to another. These are: (i) the two objects should be in contact; and (ii) their temperatures should be different. Remember that heat flows only from a hotter object to a colder one.

When we placed the spoon in the hot cup of milk, all these conditions were satisfied. The spoon and the milk were in contact and their temperatures were different. The cold spoon absorbed heat from the hot milk and its temperature increased. Let us compare the conduction of heat in various substances.

### Activity 2

Take two metal rods, one of iron and the other of aluminium. Repeat the first activity as shown in Figure 5.2. From



Fig. 5.2 Experiment to show that the conduction of heat by different materials is different

which of the two rods do the nails drop first?

You will note that nails drop from both the rods. You will also notice that the nails stuck to the aluminium rod begin to drop earlier than the nails stuck to the iron rod. Both aluminium and iron conduct heat but aluminium conducts it faster than iron. Aluminium is a better conductor of heat than iron.

Metals like silver, copper, iron and aluminium are *good conductors* of heat. Materials like wood, leather, asbestos or paper are not. In fact you can hold one end of a sheet of paper in your hands even if the other end is burning. The burning end of paper is at a very high temperature and yet none of this heat is conducted to our hand. But if we hold an iron rod at one end and heat the other end, the conducted heat can burn our fingers.

We make use of both the good and the bad conductors of heat. For example, we use cooking utensils made of metals and alloys. These are good conductors so

that the heat from the flame is conducted to the food inside quickly and efficiently. We also use bad conductors like brick and mud when we build our houses. The heat outside is, therefore, not conducted into the rooms. Roof sheds are made of asbestos for the same reason. Use is made of bad conductors to cover vehicles carrying inflammable substances like petrol. Otherwise, the petrol can get hot and catch fire.

### ANSWER THESE

1. Why is the handle of a metal kettle covered with strips of cane?
2. Why is the handle of a heating iron made of ebonite or wood?
3. What are the conditions needed for the conduction of heat?

## 5.2 Convection

### Activity 3

Take a round bottomed flask and fill it half with water. Drop some crystals of potassium permanganate in it. Now heat the flask and watch the movement of the coloured solution (Figure 5.3).

In this activity, the liquid in the bottom of the flask gets heated first. This warm liquid, being lighter than the surrounding cool liquid, rises up, the colder liquid moves down, gets heated and in turn rises again.

The heat is transferred from the hot water at the bottom of the flask to the cooler top by the actual movement of the water itself. This process of the hotter fluid moving and transferring heat to the

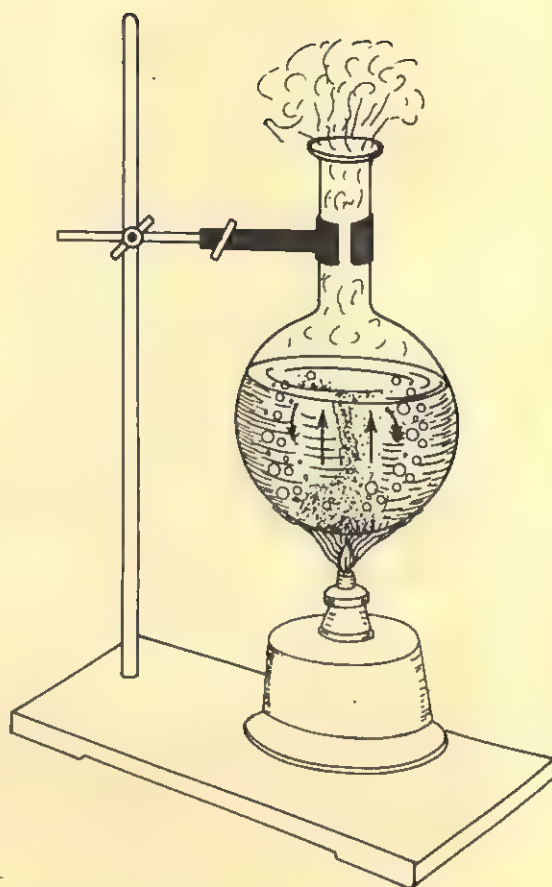


Fig. 5.3 Experiment to show the convection of heat

colder surroundings is called *convection*. If the hot water from the lower part were somehow stopped from rising, little heat would be transferred to the water in the upper part. Let us do an activity to see this.

### Activity 4

Take a test tube. Fix a piece of wax in the bottom. Now fill this test tube with water. Hold the test tube in an inclined position so that only the water in the

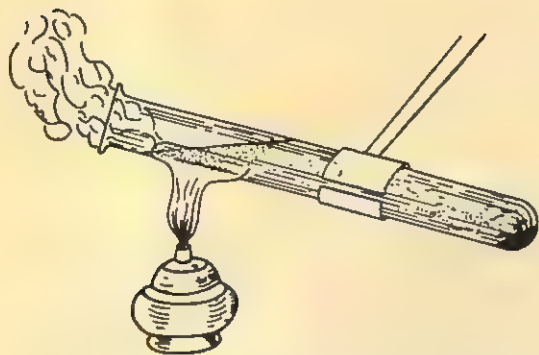


Fig. 5.4 Experiment to show that water and glass are bad conductors of heat

upper part gets heated (Fig. 5.4). Does the wax at the bottom of the test tube melt?

In the above activity, only the upper part of the water was heated. The warm water being lighter remains at the top of the test tube; it does not move down, no convection takes place and the wax does not melt.

But could *not* the heat be transferred to the wax by conduction? After all the water and the wax are in contact. But the heat from the top did not reach the bottom soon. This shows that water is a bad conductor of heat. It does not transfer heat well by conduction.

Air too is not a good conductor of heat. But being a gas, it can flow and spread fast and transfer heat by *convection*. This is why it first feels hot when the fan is turned on in a closed railway compartment. The hot air is circulated and transfers the heat to us by convection. Also, when hot air rises it also transfers its heat to the cooler surroundings.

*Only liquids and gases convect heat.* A solid cannot do so because solids do not flow like liquids and gases do.

#### ANSWER THESE

1. In convection, water travels from \_\_\_\_\_ region to the \_\_\_\_\_ region.
2. Why does sugar dissolve faster in hot milk than in cold milk?
3. Give reasons for the occurrence of storms.

#### 5.3 Radiation

There is a third way by which heat can be transferred from a hot body to a cooler one. This mode of transfer is called *radiation* and it does not need any medium between the two bodies. It lets out heat *rays* to the surroundings just as a bulb or a candle lets out light rays. This is why this manner of transferring heat is called radiation. The hot object radiates heat rays to the colder surroundings.

All hot objects transfer heat by radiation, whether they are solids, liquids or gases. Radiation needs neither a conducting medium nor convecting fluids for transfer. It occurs even in vacuum. This is how we receive heat from the sun. The sun radiates heat rays in all directions, which travel all the way to all the planets.

The amount of heat absorbed by a body depends on the distance between it and the source of the radiation. The farther the two are, the smaller the amount of heat transferred. The planets

that are farther away from the sun receive less heat radiation from the sun than the earth does. They are thus colder than the earth.

In Table 5.1 are given the distance of the nine planets from the sun, and their temperatures during daytime and night-time.

TABLE 5.1

Distance of the Planets from the Sun and their Average Temperature

Planet	Distance from Sun in Million Kilo metres	Temper- ature in Degrees Celsius	(Average)
		Night	Day
Mercury	58	-260	+410
Venus	108	- 40	+450
Earth	149	+ 2	+ 40
Mars	227	-100	+ 35
Jupiter	775	-150	+ 40
Saturn	1416	-170	+ 50
Uranus	2866	-170	-150
Neptune	4493	-170	-150
Pluto	5904	-170	-150

Note that the *inner planets*, Mercury, Venus, Earth and Mars are warmer than the outer planets like Saturn or Uranus. This is a direct result of the distance between each planet and the source of the heat, the sun.

The second thing to notice is the temperature variations in the daytime and night-time of each planet. This depends on the atmosphere around the planet.

Uranus, Neptune and Pluto have no atmosphere around them that would act as a heat insulator. And they are very far from the sun. They are thus very cold all the time.

Mercury and Venus, the sun's nearest neighbours, have atmospheres which give a heat coat around them. But the planets are just too near the sun so that they cannot avoid getting too hot in daytime. When the sun sets, they get too cold. Only Earth and Mars have the right balance of the distance from the sun and the atmospheric coat. This prevents large variations in their temperatures between daytime and night.

There is another interesting fact about heat radiation. The amount of heat that a body can absorb by radiation depends on the colour of the body. Let us do an activity to check this.

### Activity 5

Take two tin cans of the same size and paint one of them black. Pour equal amounts of water in each and leave them in the midday sun for one hour. Measure the temperatures of the water in each of them. Which water is warmer?

You will notice that the water in the black tin is warmer. The darker body has

absorbed more heat radiation than the other one.

You can also do the reverse experiment by taking hot water. Heat water to the same temperature (say  $70^{\circ}\text{C}$ ) and take equal amounts in each can. Leave the cans in a shady place for 10 minutes and record the temperature in each case. You would find that the water in the black can has cooled down more. Thus, we conclude that darker bodies absorb radiation and also emit radiation better than bodies of lighter colours.

#### ANSWER THESE

1. Why is sunlight hot while moonlight is "cool"?
2. Why do people prefer to wear white clothes in summer?

#### YOU NOW KNOW

- Heat is transferred from a hotter body to a colder one in three ways—conduction, convection and radiation.
- Transfer of heat stops when the temperatures of the two bodies is the same.
- A solid transfers heat to another solid in contact with it by the process of conduction.
- Metals like iron, silver, copper are good conductors of heat compared to wood, paper and glass.
- Transfer of heat in liquids and gases takes place by convection.

- Transfer of heat from a hot object to a cold one without any medium in between is called radiation.
- We receive the heat from the sun by radiation.
- Dark objects are better absorbers of heat by radiation than bright objects. They also emit radiation better.

#### NOW ANSWER THESE

1. When cold milk is added to hot tea, how does the heat transfer take place?
2. A cold spoon is dipped in a hot cup of tea. By which process does the spoon absorb heat from the tea?
3. Look at Figure 5.4 and the Activity 4. Suppose we had the piece of wax floating on the water surface and we heated the water from the bottom of the test tube. Would the wax melt soon? Why?
4. If a spoon is held over a fire, it becomes hot after some time. Describe the process of heating up.
5. Why is it better to wear bright clothes in summer and dark clothes in winter?
6. If I add 100 ml of cold water (at a temperature of  $20^{\circ}\text{C}$ ) to 100 ml of hot water (at a temperature of  $60^{\circ}\text{C}$ ), what will be the final temperature?
7. We use thermos flasks to keep liquids hot (tea) or cold (ice water) for a long time. The flask is usually a double walled glass vessel. The surface of the glass is silvered like a

mirror, and the space between the walls is evacuated. This is why it is also called a *vacuum flask*. Now answer the following:

- i. Why is glass chosen as the material for flasks?
- ii. Why is the surface silvered?
- iii. Why is the space evacuated?

## Light and Shadows

LIGHT IS NEEDED TO SEE things. We may have keen eyesight and the object we wish to see may be as large as a house. Yet, can we see it in the dark? We need a source of light to make objects visible. We will learn in this chapter about many interesting properties of light.

### 6.1 Sources of Light

An object that gives out light is called source of light. The most important light source for us is the sun. It is a very bright source. Even though it is 150 million kilometres away, it makes the daytime bright for us on earth. The sun is of course, a *natural* source of light, and not artificial or made by man. Stars are other natural light sources. Some of them are even brighter than the sun. But they are so far away from us that they are seen at night only as twinkling points in the sky. The glow-worm or the firefly (*jugnu*) is another natural source of light. It looks pretty in the dark night, but its light is not enough to read a book by.

There are other sources of light that are not natural but *man-made*. The candle, the oil-lamp, and the torch are some examples of man-made sources of light.

Some light sources are brighter than others. A firefly is a very feeble source of light. A candle is brighter than the firefly. An electric bulb is far brighter than the candle. In fact, the brightness or the *luminous intensity* of a light source used to be measured in comparison to the brightness of a candle, in units called the *candle power*. An electric bulb used at home is about 100 or more candle power. This means that about 100 candles give the same brightness as the electric bulb. The noontime sun is more than a million candle power in brightness. The modern internationally accepted unit of brightness of a source is the *lumen*. One lumen is equal to 12.56 candle power. (And about 700 lumens is equal to 1 watt).

The light from a source such as a candle or an electric bulb or the sun spreads in all directions from the source. It gets dimmer as we move away from it. The brightness at a given surface is measured in units of lumen per unit area called *foot candles*. The modern unit is the *lux* (1 foot candle = 10.76 lux).

#### Activity 1

Take a candle and light it in a dark room.

Take a piece of cardboard and pierce a hole in it. Place this board in front of the candle so that it casts a bright spot on paper held in front of the hole (Figure 6.1). Hold the paper first 30 cm away from the cardboard and look at the spot of light falling on it. Now hold it 60 cm away, and then 150 cm away and look at the light each time. Does the brightness of the spot remain the same?

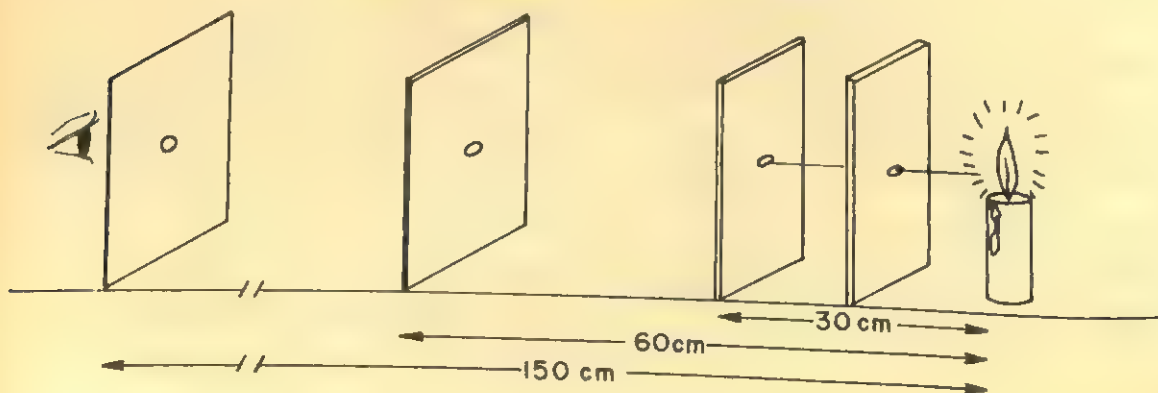
Many light sources often give out heat as well. An electric bulb heats up as it glows. However, a tubelight gives out much less heat than a bulb. The sun, of course, gives both heat and light. A firefly, on the other hand, is a cold source of light. You can actually test this by catching a few fireflies and feeling them. A firefly gives out as much light as an *agarbatti*. If its body temperature were as high as the tip of an *agarbatti*, the firefly would have easily burned itself.

Why are some light sources hot and others cold? The reason lies in the way light is produced in these sources. The electric bulb has a wire inside called the

*filament*. Unless the filament is heated to a high temperature, it will not glow. The filament is heated by passing an electric current through it. A hot filament that glows is said to be *incandescent*. A tubelight does not use a filament but a different mechanism. Hence the tubelight is a cold source. You can actually touch a lighted tube, but beware of touching a glowing bulb! You can get burns on your fingers. The energy of some chemical reactions within the firefly is released not as heat, but as light. Hence the firefly is a cold light source. The sun is literally a burning globe. The reactions that take place within the sun are very powerful. The energy released in such reactions comes out both as heat and light. The sun and stars are, therefore, sources of both heat and light.

The burning candle, the firefly, lamps and the sun are sources of light. They are thus called *luminous* objects. The moon is not a luminous object. It is a reflector of the sun's light. The moon is

Fig. 6.1 Brightness diminishes with distance.



thus only a cold *non-luminous* mirror. The only objects in the sky that are natural sources of light are the sun and the stars. The planets and the moon are only reflectors. Just like moonlight, one can talk about earthlight. *Earthlight* would be the light of the sun reflected from the surface of the earth. The astronauts who went to the moon did see earthlight there. There is one indirect way by which we can see the earthlight too, sitting right here on earth. To see how, let us take a look at the various phases of the moon.

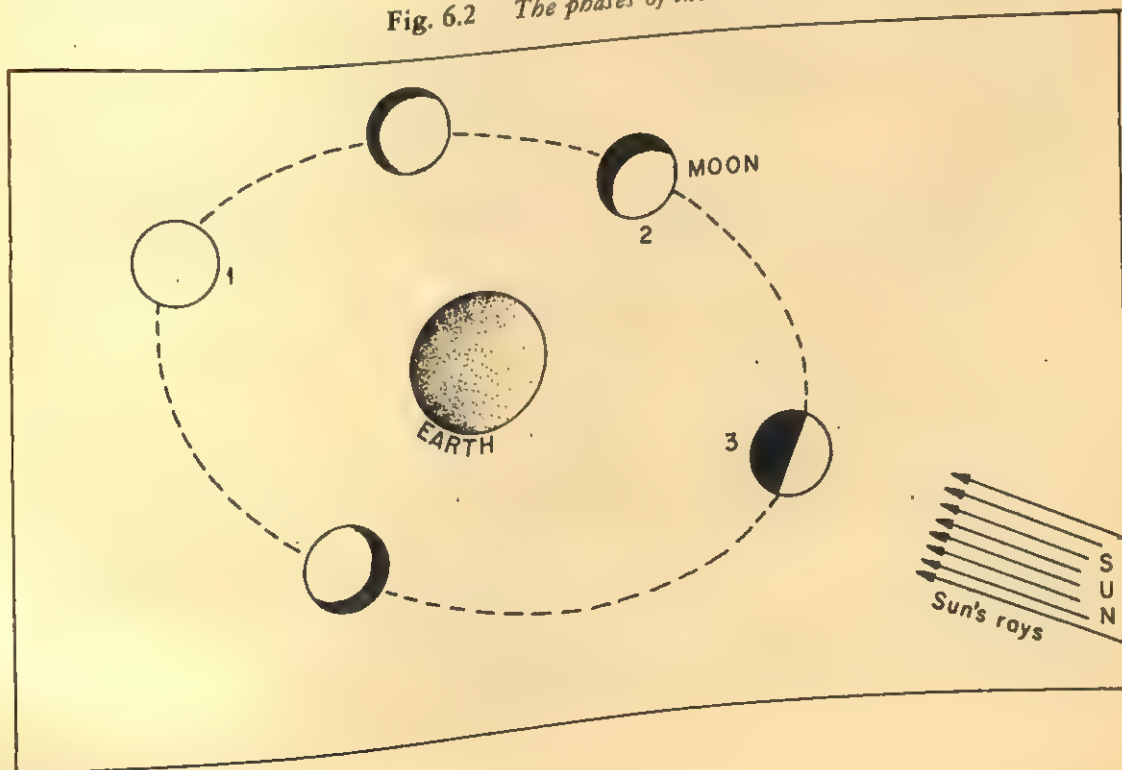
## 6.2 The Phases of the Moon— Heavenly Play of Light

Not only does the moon revolve round

the earth, it also revolves round the sun, along with the earth. Figure 6.2 shows various stages of the moon's path round the earth.

In position 1, the sun's rays fall directly on the moon and we see the moon as a full disc of light. We call this the full moon. As it moves round the earth, we can only see that part of the moon that is lighted up by the sun and is towards us. Thus, in position 2, we see the moon not as a full disc but as a crescent. In position 3, the part of the moon facing the earth is dark. It is not lit by the sun. It is the other part that is facing away from us which is now lit. We now have the new moon in position 3. During the positions 1, 2 and 3, the

Fig. 6.2 The phases of the moon



moon wanes, that is, the bright portion of the moon becomes smaller and smaller as it moves from 1 to 3. Between positions 3 and 1, it is in the waxing phase, that is, the bright portion of moon increases. Thus we have *puṇnima* (position 1) waning in two weeks of the *krishna paksha* into the *amavasya* (position 3), which again grows during the fortnight of the *sukla paksha* into *puṇnima*.

Immediately following the new moon day, you can see a crescent moon on the western horizon, just after sunset. The crescent is that portion of the moon which is illuminated by sunlight. The rest of the moon is also faintly visible. Why is it visible? Because it is illuminated by light reflected from the earth, that is, by *earthlight*! The sunlit part of the moon is, of course, much brighter than the earthlit part.

#### ANSWER THESE

1. List four natural sources of light.
2. Write down five man-made sources of light.
3. What is meant by luminous intensity? And what is a lumen?

### 6.3 Light Travels in a Straight Line

In order to find out how light travels, let us do some activities.

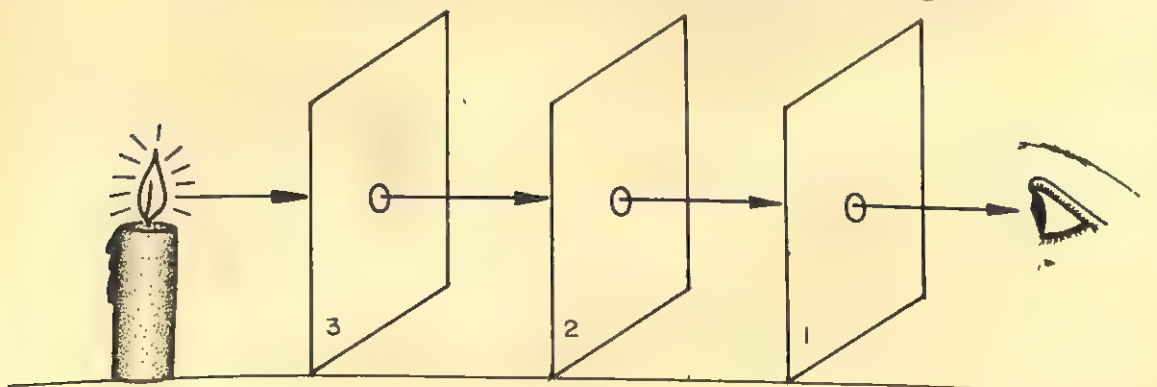
#### Activity 2

Take a lighted candle and place it on a table. Take a rubber tube and look through it at the flame. First, stretch the tube straight and look. Can you see the flame? Now bend the tube and look through. Can you see the flame? What is the best shape of the rubber tube that helps you see the flame?

#### Activity 3

Take three cardboards of the same size. Stack them together and make a hole in each by driving a nail through all of them. Mount each cardboard upright on the table using moulding clay, plasticene or even kneaded *atta* (dough). See Figure

Fig. 6.3 Experiment to show that light travels in a straight line



6.3. Take a candle with the wick at about the same height as the hole in the upright cardboard. Mount the candle and light it. Adjust the three cardboards 1, 2 and 3 so that you can see the flame through 3.

Now check if all the three holes are in a straight line. You can use a needle and thread to check this. These activities show us that light travels in a straight line.

#### Activity 4

**Make a periscope:** You would need a cardboard box, two small mirrors, black paper or plastic, rubber band, scissors or razor and tape.

Cut slits at  $45^\circ$  angle in both sides of a cardboard box. Push a small mirror through each of the slits from side to side. The reflecting side of one mirror must face the reflecting side of the other. Cut peepholes opposite the reflecting sides of the two mirrors. Cover the end of the box with black plastic paper with rubber bands and tape. Now you can see from the bottom of the periscope. You can see above an obstacle as in Figure 6.4.

#### 6.4 Shadows

Some materials allow light to pass through them and some do not. You can look at a lighted candle through a clear glass or some kinds of plastic sheets. These allow light to pass through them. Such materials are called *transparent*. Now look at the candle through ground glass or a sheet of butter paper. You can

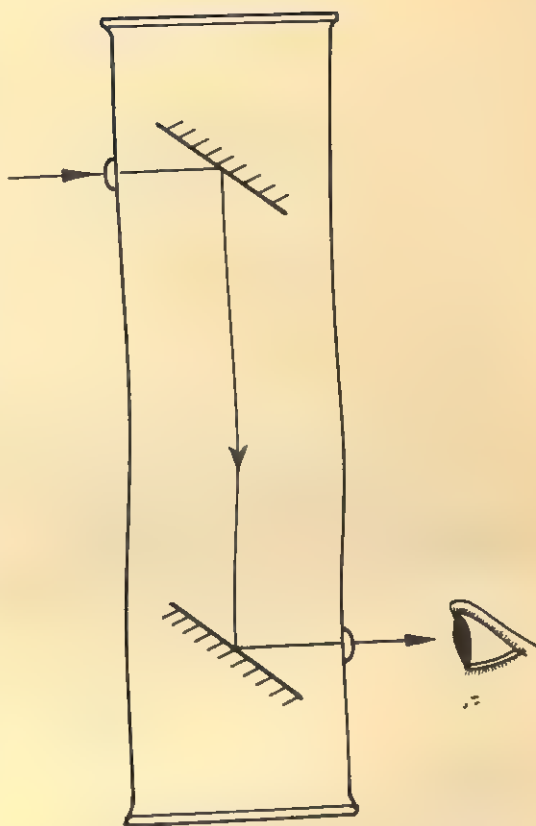


Fig. 6.4 A periscope

see some dim light, but not the wick of the flame clearly. Those materials that allow light to pass through them only partially are called *translucent*. If you had used a notebook you would not have been able to see even the blur of the candle. It will stop the light of the candle flame from reaching your eyes. The notebook is, therefore, called *opaque*.

Now take a paper from the notebook and see how much light passes through. Next, rub some oil on the notebook paper. The portion where the oil soaks through will allow some light to pass

through. The oiled paper is, therefore, translucent.

Thus objects can be transparent, translucent or opaque to light.

Shadows are produced when light is stopped by objects. An opaque object casts a dark shadow, a translucent object a weak one and a transparent object no shadow at all.

When we walk in the sun, our shadow moves with us. Our shadow is very long in the morning when the sun rises. Then its length goes on decreasing till noon. Our shadow is shortest at noon. Its length again goes on increasing in the afternoon and becomes very long just before the sunset. Why is this so? Do the shadows always fall in the same direction? Let us perform an activity.

#### *Activity 6*

Take a wooden stick about half a metre long. Fix one end of it in an open field or ground away from trees and buildings. Look at its shadow in the morning when you reach the school. Make a chalk mark where the shadow falls. Note the direction of the sun with respect to the stick. Is the shadow on the same side of the stick as the sun? No, it is formed on the side opposite to the direction of the sun.

Now look again at the shadow around 11 a.m. Is the shadow in the same direction as in the morning? Is there any change in the length of the shadow? Now again look for the shadow at noon. How is the shadow different compared

to morning. Observe the shadow around 2 p.m. You will find that the shadow lies in a direction opposite to that seen in the morning. Note the direction of the sun and the shadow.

What can we say now about shadows?

- (i) The shadow of an object is formed in the direction opposite to the side of the light source.
- (ii) When the source of the light or the object moves the shadow also shifts accordingly. In our activity the shadow of the ruler shifted as the position of the sun in the sky changed.
- (iii) The length of the shadow formed by sunlight changes with time. This is because the angle between the source, the object and the ground changes.

There is another interesting fact about shadows which helps us to measure the length of an object. By measuring the length of the shadow formed by a tree or a building in sunlight, we can calculate its height. The following activity shows how this is done.

#### *Activity 7*

The aim is to measure the height of the tree without having to climb it. For this, choose a sunny day and put up a metre stick erect near the tree. In Figure 6.5, AB is the metre stick and TR is the height that we want to find out. AB drops the shadow BC on the ground and the tree drops its shadow RS. The sun is so far away from the tree and the metre

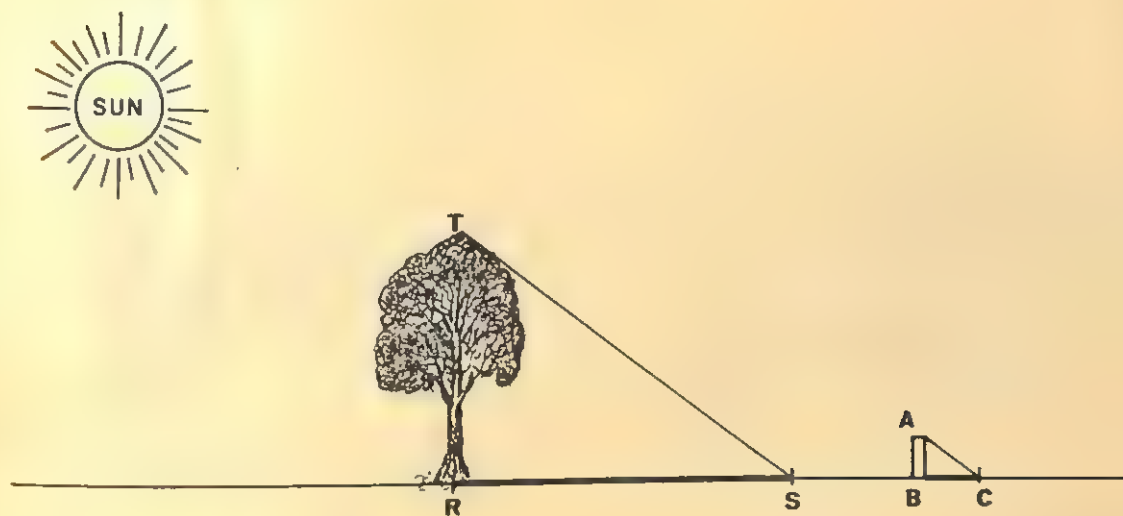


Fig. 6.5 Using the ratio method to measure the height of a tree

stick that the lines TS and AC are parallel. This makes the ratio  $BC/AB$  equal to the ratio  $RS/TR$ . Now measure the distance BC using another metre stick or measuring tape. You already know  $AB = 1$  metre. Now you can calculate the height of the tree TR if you measure the length RS. Measure RS using a metre stick or a tape. You have  $BC/1 \text{ metre} = RS/TR$ . Therefore,  $TR = RS/BC \times 1 \text{ metre}$

You have thus measured the height of the tree without climbing it, by using this ratio method.

#### ANSWER THESE

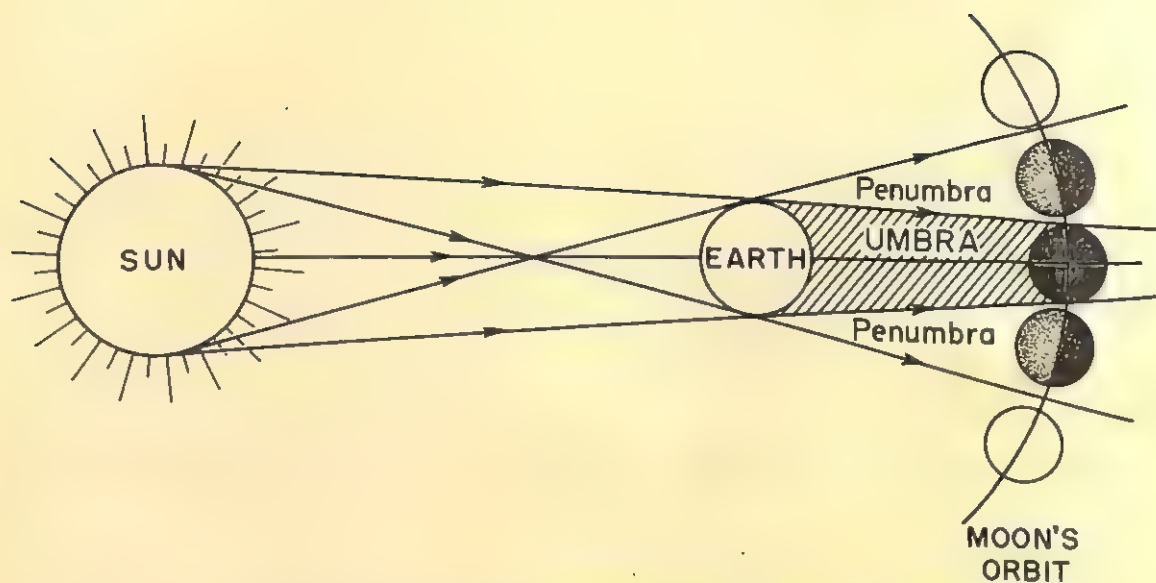
1. Distinguish between transparent, translucent and opaque objects.
2. A metre stick dropped a shadow of length 70 cm in the sun. At the same

time, a tree dropped a shadow 5.6 metres long. What is the height of the tree?

3. Is there a particular time on a sunny day when this ratio method may not work?

#### 6.5 The Eclipses

We see shadows being cast on the ground every day. Similarly, the earth, the moon and the planets also cast their shadows in space. However, we cannot see these shadows unless they fall on some surface or object. The shadows of birds flying at a great height cannot be seen on the earth but, we can easily see their shadows when they fly nearer the ground. (Can you name some of the objects of which we see the shadows in daily life?) Some times, on a full-moon day, the moon passes through the



**Fig. 6.6** *Lunar eclipse. In the region called umbra, light is completely cut off. But in the penumbra region, some dull lighting will persist. This is because the source of light (the sun here) is not a point but a large object. With point sources, there will be no penumbra. Can you say why?*

shadow of the earth. When this happens, we cannot see the moon's disc until the moon comes out of the shadow. A lunar eclipse occurs in this way. Figure 6.6 shows the picture of a *lunar eclipse*.

If the entire disc of the moon passes through the shadow, we observe a total lunar eclipse. If only a part is covered by the shadow, we call it a partial lunar eclipse. The width of the earth's shadow at a distance of 400,000 km is nearly three times the moon's diameter. You will, therefore, never observe an *annular* lunar eclipse. An annular eclipse is one in which only the central part of the moon's disc is covered with the shadow, leaving a bright rim visible.

On the new-moon day, if the sun, the moon and the earth are in a straight line, the shadow of the moon can fall on the earth. If we are in this shadow, we will not be able to see that part of the solar disc which is covered by the moon. That is what happens in a solar eclipse.

The moon is small but near to us. The sun is very big but further away from us. It is entirely by chance that the sun and the moon appear to have approximately the same size when viewed from the earth. This would make a total or annular eclipse of sun by the moon difficult. However, the path of the moon round the earth, and that of the earth round the sun are not perfect

circles. The apparent sizes of the lunar and solar discs, therefore, change slightly. Hence occasionally it is possible for a solar eclipse to be total or annular. Partial solar eclipses are, of course, much more common.

You might wonder why an eclipse does not occur every full-moon day or every new-moon day. The plane in which the moon moves round the earth and the plane in which the earth moves round the sun are not the same. They are slightly tilted with respect to each other as shown in Figure 6.7.

As a rule, therefore, the shadow of the moon misses the earth on the new-

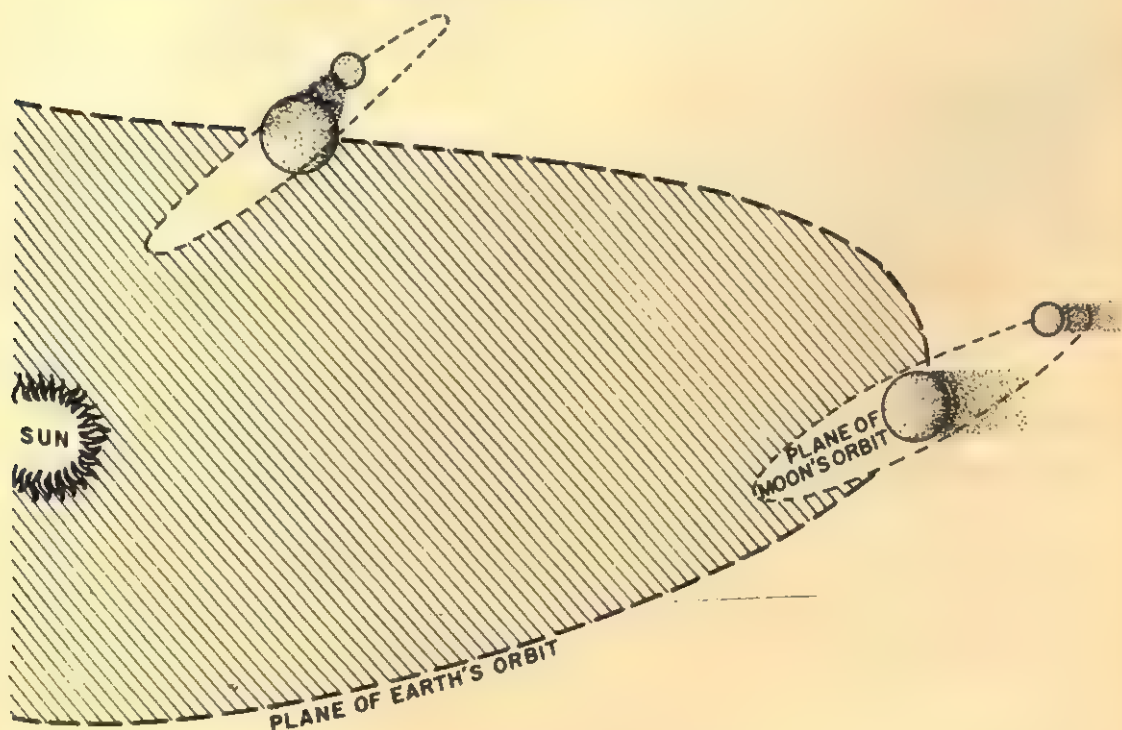
moon day, and the shadow of the earth misses the moon on a full-moon day.

If, however, the full-moon day or the new moon day occurs when the moon is at the point where the two planes cross, then the sun, the moon and the earth are in a straight line, and eclipses occur.

The eclipses are simply a play of shadows. Knowing the movements of the sun, the earth and the moon, we can *predict* the time and the date of an eclipse. Such predictions of when the lunar and solar eclipses will occur are found in some books such as the *panchanga* or the almanacs.

You can watch the moon and a lunar

Fig. 6.7 *The plane of the moon's orbit round the earth is slightly tilted from the plane of the earth's orbit round the sun.*



eclipse directly with the naked eye. *But you must never watch the sun without protecting your eyes.* This is because direct rays of the sun are very strong, even in a solar eclipse. If you wish to see a solar eclipse, take a piece of plane glass (not curved, since that can be dangerous) and blacken it with soot. It should be so black that nothing except the sun should be visible through it. Use this glass to look at the sun. Alternatively, take a piece of cardboard with a pinhole at the centre. Using this cardboard you can obtain an image of the sun on the wall. You can look at this image on the wall safely. But do not ever look at the sun directly! Your eye could be damaged.

#### ANSWER THESE

1. Write down the names of five translucent objects.
2. Are there situations or conditions when pure water can lose transparency? Hint: You can change the temperature of water.
3. Fill in the blanks.
  - (i) Solar eclipse occurs only on \_\_\_\_\_ moon days.
  - (ii) Lunar eclipse occurs only on \_\_\_\_\_ moon days.
4. Why should you not look at the sun or a solar eclipse directly?

#### YOU NOW KNOW

— There are natural and man-made sources of light.

- The brightness of a source is measured in foot candles.
- There are luminous and non-luminous objects. The moon and the earth are examples of the latter.
- Objects are transparent, translucent or opaque to light.
- Shadows are formed when light is blocked.
- Shadows can be used to measure heights of tall buildings and trees.
- Eclipses are a play of shadows in the sky.
- Never look at the sun or a solar eclipse directly.

#### NOW ANSWER THESE

1. Name some sources of light that are not hot.
2. Which of these objects are luminous: camera, firefly, mirror, a car bumper, filament of a bulb, diamond?
3. "The tube light is a cold source of light." Is this statement true? If so, Why?
4. Explain what is meant by earthlight.
5. Draw the diagram of a solar eclipse.
6. The height of a tree is measured by measuring its shadow length and using the ratio method. Can you do this at any time of the day—morning or afternoon? Why?
7. What should be the shape of an object so that it will cast no shadow (or very little) on the ground in sunlight?

## Mirrors and Reflection of Light

WE ARE ALL FAMILIAR with mirrors. We see them in our homes, in shops and in cars. We know that polished shiny surfaces act as mirrors. What happens when light falls on a mirror?

When light falls on any object, it is allowed to pass through, stopped or absorbed by the object, or scattered off. What do mirrors do that just transparent glass sheets do not? Let us look at the matter in some detail in this chapter.

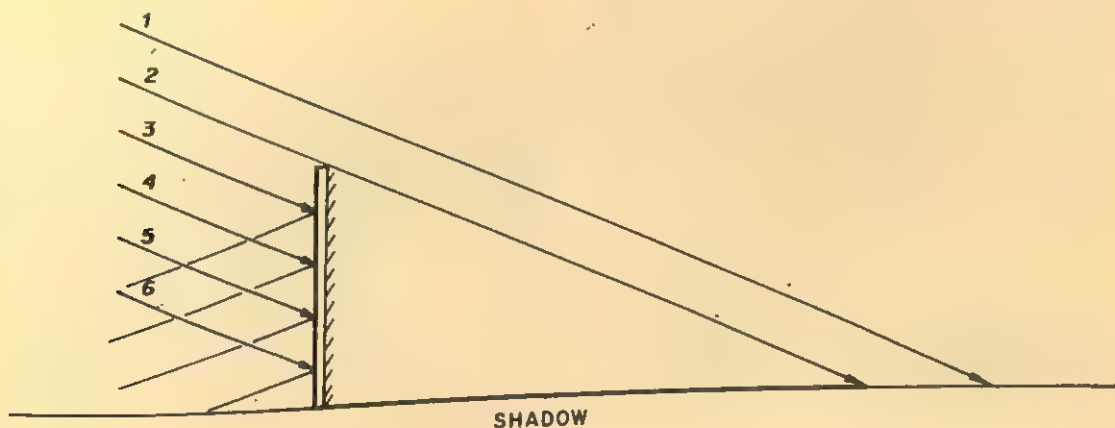
### 7.1 Reflection of Light

What does an object do to the light that falls on it? It may allow the light to pass

through, as a glass sheet does. Or it may completely cut off the light from passing through by absorbing the light. The object is then called opaque. Or, the object may scatter the light incident on it. This is shown in Figure 7.1, where light is falling on a mirror.

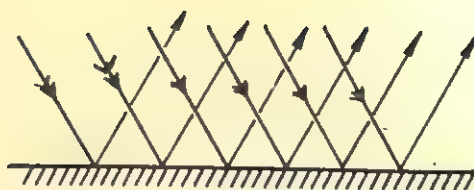
To make a mirror, a sheet of glass is silvered on one side. A coat of dark paint is then given to protect the silvering. No light passes through the mirror, but is stopped and so a shadow of the mirror is seen behind on the ground. The light beam (1) above the mirror passes unstopped. Light ray (2) just defines the

Fig. 7.1 Reflection of light and formation of a shadow





UNEVEN SURFACE  
IRREGULAR REFLECTION



EVEN SURFACE  
REGULAR REFLECTION

Fig. 7.2 An uneven surface reflects light irregularly.

length of the shadow. Rays (3), (4), (5) and (6) are stopped by the mirror. Instead of passing through, the mirror surface bounces them off like a smooth wall bounces a ball. These rays are scattered back or *reflected*. This scattering back is called *reflection*.

In Figure 7.2, we compare the reflection of light from a smooth and an uneven surface.

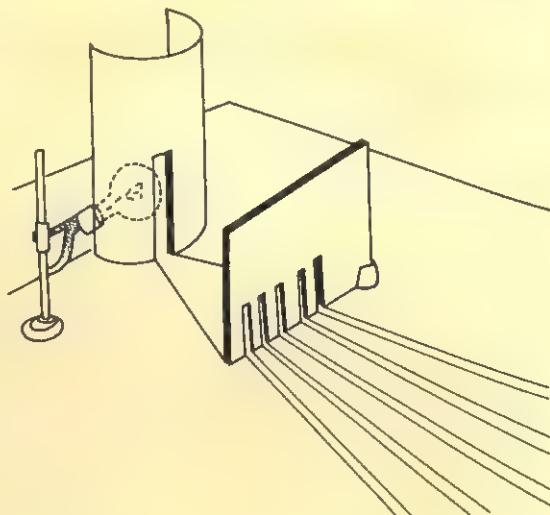
The reflected rays from an uneven surface are scattered in all directions. This is why a mirror that has lost its smoothness does not give a clear image. On the other hand, the smooth surface gives a clear image due to regular reflection.

What is the best mirror or an ideal mirror? What we would like of a mirror is that it reflects best. There should be little or no transmission, otherwise we would not have a mirror. We would not like to lose the light by absorption either. The best would be to have the maximum reflection. This is achieved by having a smooth and shiny surface. The shiny surface helps in reducing the

absorption. The smoothness helps in forming a clear image. This is why a silvered glass is used in a mirror. The glass offers a smooth surface. Silvering makes it shiny and the red paint in the back reduces transmission and protects the silvering.

We can study the reflection of light in some detail using a ray box. This has an electric lamp inside a dark box with a wide slit, as shown in Figure 7.3. There is also another darkened tin sheet with one

Fig. 7.3 The ray streak apparatus



or more slits. This tin sheet is placed in front of the box to get a beam of light.

Take a plane mirror  $MM'$  and place it on a white sheet of paper in such a way that the shining surface faces the ray box. Let us shine a beam of light by opening only one slit from the ray box on this mirror. We find that the beam of light visible on the paper is reflected. We show this in Figure 7.6. Let  $O$  be at the point at which the incident ray  $AO$  strikes the mirror. The point  $O$  is called the *point of incidence*. The ray of light that falls on the mirror from the source is called the *incident ray*. The incident ray  $AO$  strikes the mirror and is reflected along the path  $OB$ .  $OB$  is, therefore, the reflected ray. At  $O$  draw a perpendicular  $ON$  on the mirror  $MM'$ .  $ON$  is called the *normal line* or simply *normal*.

The angle between the incident ray and the normal is called the *angle of incidence*,  $\angle i$ .  $\angle AON$  is the angle of incidence. The angle  $\angle BON$  between the reflected ray and the normal is called the *angle of reflection*,  $\angle r$ .

If we measure the angle of incidence ( $\angle i$ ) and the angle of reflection ( $\angle r$ ) we will find that they are equal. If we change the angle of incidence the new angle of reflection will be equal to the new angle of incidence. If the incident light is along the normal, the reflected ray will travel back along the normal. Hence the angle of incidence is zero and so is the angle of reflection. Thus, for all values of  $i$ ,  $\angle i = \angle r$ .

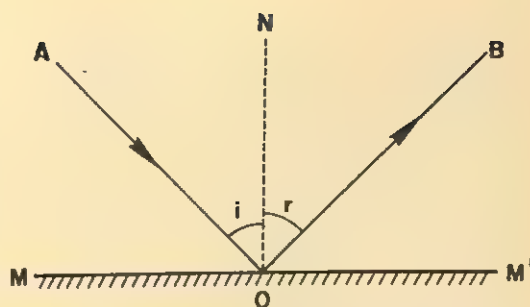


Fig. 7.4 The Laws of Reflection:  $i$  is the angle of incidence and  $r$  is the angle of reflection.

We can also notice from Fig. 7.4 that the incident ray, the reflected ray and the normal, all lie in the same plane

In summary, we notice that:

- (i) the angle of incidence is always equal to the angle of reflection.
- (ii) the incident ray, the reflected ray and the normal to the mirror at the point of incidence, all lie in the same plane.

These two statements are always true for reflection of light and are called the *Laws of Reflection*.

#### ANSWER THESE

1. What are the laws of reflection of light?
2. How many reflected rays can there be for a given single incident ray falling on a plane of mirror?
3. Can you guess how light would be reflected from a mirror if the angle of incidence is 90 degrees?

The two laws of reflection are not special only to light. When you play the game of carrom, you use these laws—particularly when you hit 'back shots' (Riff) or 'angle shots'. The walls of the carrom board must be smooth, polished and not chipped. Only then can these shots be played properly. The walls then act as mirrors and reflect the striker or the coins. The board is also powdered so that its surface is smooth and has no friction. Then the striker and the coins move effortlessly. See how similar this is to the situation in Figure 7.4.

## 7.2 Image Formed by a Plane Mirror

Have you ever thought why and how your image in a plane mirror looks different from you? If you move your right hand, which hand does your image move? Think carefully. Similarly if you touch your right eye with the right hand, which eye does your image touch? You will find that the '*left appears right*' and the '*right appears left*' in the mirror. This phenomenon is called *lateral inversion*. We, therefore, say that the image formed by a plane mirror is laterally inverted.

Write the word *LEFT* on a piece of paper and hold it in front of a plane mirror. How does it appear in the mirror? Which letters remain unchanged?

Write all the letters from A to Z and find out those letters whose images in the mirror appear to be the same as the original letters. H and O are two examples.

The image formed by a plane mirror is of the same size as the object. The image is also erect. It means your 'top' does not become 'bottom' in the image formed in the mirror. You also know that if you move close to the mirror, your image also moves closer. Similarly, if you move away from the mirror, your image also moves away. This is another feature of the image formed in a plane mirror. The distance of the image from the mirror is equal to the distance of the object from the mirror. Lastly, the image formed of an object by a plane mirror is *virtual*. It means that we cannot obtain the image formed in a mirror on a screen placed anywhere behind the mirror. The image which can be obtained on the screen is called *real* image.

## SPHERICAL MIRRORS

Plane mirrors give images that are erect and of the same size as the object. What about mirrors that are not plane but curved? Such curved mirrors produce distorted and often funny images that are smaller or larger than the object.

Take a shining steel spoon and look at your image using the front of the spoon and using the back of the spoon. The two images are different, and each is different from what you get from a plane mirror. The inner side or the front of the

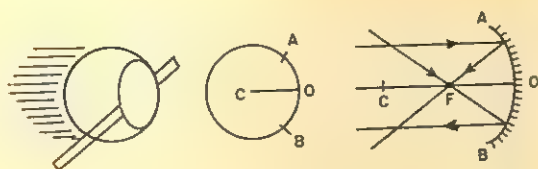


Fig. 7.5 Cutting a portion of a hollow sphere to make a concave mirror. AOB is the mirror, C is the centre and F is the focus.

spoon is curved inwards at the middle. It acts as a *concave* mirror. The outer side or the back of the spoon curves outwards and is a *convex* surface. The convex, concave and plane mirrors all act very differently from one another. We see all these mirrors used in our daily life. Convex and concave surfaces are really segments of a hollow sphere, like a tennis ball. The outside surface is convex while the surface facing inside is concave, as shown in Figure 7.5. If we cut out the segment AOB and silver it inside and paint it dark outside, it will be a concave mirror. How does a concave mirror reflect light? Let us see this in some detail.

The line connecting the centre C to the middle point O of AOB is called the *principal axis*. Light rays parallel to CO will be reflected but not sent back in other directions. They will all converge or go through in one point F. F is called the *focus* of the concave mirror. Interestingly for this concave mirror, the focal length FO is always half the radius. CO, that is,  $FO = \frac{1}{2} CO$ .

The laws of reflection are the same for the plane mirrors and for curved mirrors. The angle of incidence is equal to the angle of reflection in both cases. Look at the ray PQ falling on the concave mirror in Figure 7.6. How would it be reflected? Remember that the mirror is the arc of a circle of radius OC. Also note that  $OC = QC$  and QC is the normal at Q. Now we can draw the ray diagram such that the incident angle and reflection angle are equal. Where the reflected ray intersects the principal axis CO is the *Focus* or *Focal Point* F.

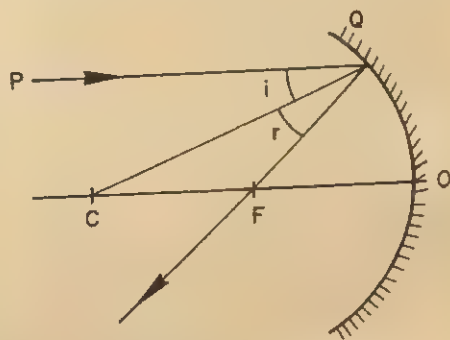
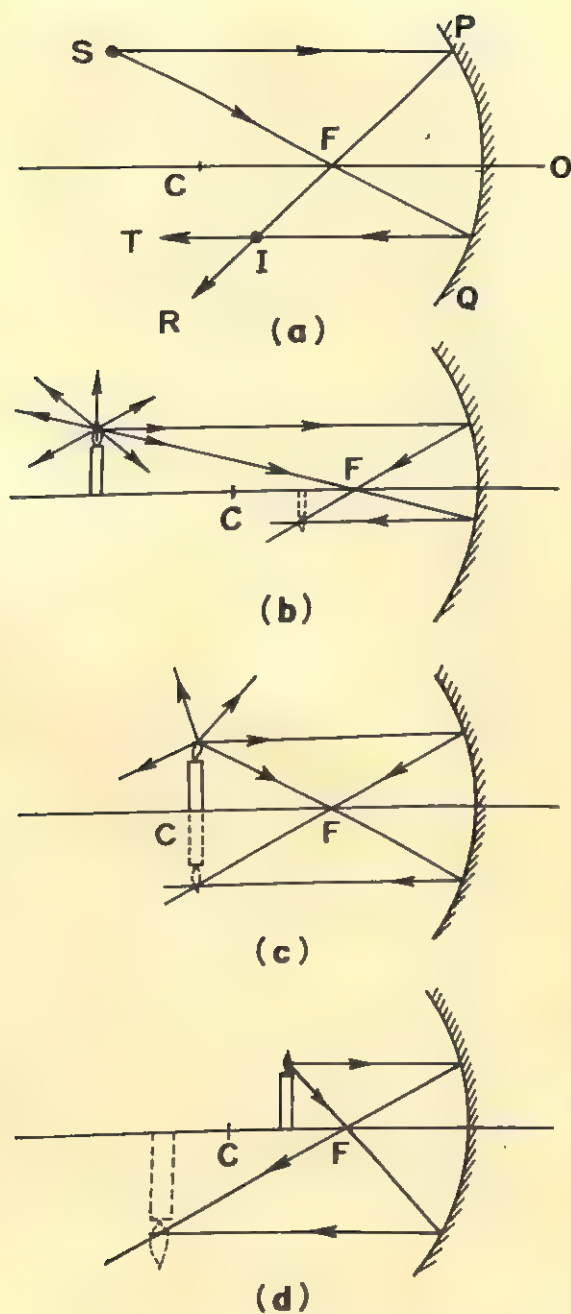


Fig. 7.6

The law of reflection in a concave mirror is the same as in a plane mirror.

Since the angle  $i$  is always equal to the angle  $r$ , all reflected rays will pass through F. And  $OF = \frac{1}{2} OC$ , always.



**Fig. 7.7** Formation of an image at point I for an object at point S. The position of the image depends on the position of the object.

### What and Where will the Image be?

We know that the image of an object formed by a plane mirror is *virtual*. It cannot be obtained or projected on a screen. That is because it is not focussed into a region or a point. But the concave mirror produces an image and focusses it. This image is thus *real* and can be captured on a screen. Where will the image be? To understand this, let us think of the point S as the object. The ray SP is parallel to the principal axis of the mirror and will be reflected passing through F as PFR. See Figure 7.7a for how it does so. The ray SF passing through the focus F hits the mirror at Q and gets reflected parallel to the principal axis as QT. These two reflected rays meet at the image point I. The object S is seen as the image I.

Notice some interesting things about I. Firstly, S is above the principal axis, I is below it. Secondly, S is farther away from the mirror while I is nearer to it. What else will it look like? Let us not use a point but a candle as the object. Look at Figure 7.7 b, c, and d. It is clear that:

- (i) When the object is placed beyond C, the image formed is nearer and smaller. It is also upside down—not just lateral inversion as with plane mirrors.
- (ii) When the object is placed at C, the image formed is also at C, of the same size and upside down.
- (iii) When the object is nearer than C to the mirror, the image is farther

away, larger in size and inverted again.

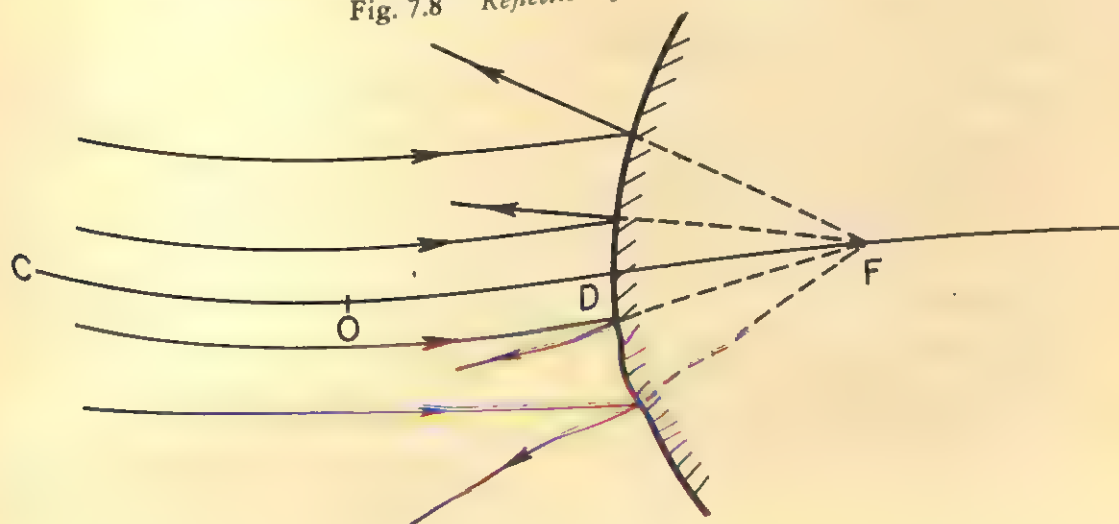
With a plane mirror, we cannot enlarge or contract the image, and neither can we capture it as a real image. With a concave mirror, we can get a real image and can change its size as well. The centre point C and the focal point F are two important features of a spherical mirror.

Look at Figure 7.7. Suppose we keep a light source at F. How will the light be reflected by the mirror. The answer is obtained by inverting the arrows in the figure. That means that the reflected rays are from a parallel beam of light. Light from the source is collected and sent out as a parallel beam. This property of concave mirrors is used in designing the headlights of cars, train engines, searchlights and even torchlights. That is why the torchlight has a

silvered cup behind the bulb. This cup acts as a light collector and reflector.

What about a convex mirror? Look at Figure 7.7 again. If the segment AOB is taken and silvered *outside* and painted dark *inside* we will have made a convex mirror out of it. The principal axis of this mirror is COD, just as with the concave mirror. What happens when light rays parallel to CFO fall on the convex surface? We can imagine them to be focussed virtually at F and diverging off or scattered as shown in Figure 7.8. The focal point is not outside the mirror, it is a virtual point. The image of the object will thus be virtual and smaller than the object. This means a convex mirror will have a wider angle or field of view than a concave or a plane mirror. We can use a convex mirror to see what is behind us rather well. The rear view mirrors in cars, scooters, buses and trucks are

Fig. 7.8 Reflection by a convex mirror



convex mirrors. The driver looks at the rear-view mirror to find out the traffic following him.

### ANSWER THESE

1. Why do we need a shiny surface for reflection?
2. Look at Fig. 7.7d. Is the image real or virtual? Why?

### YOU NOW KNOW

- Light is absorbed or scattered by objects.
- A mirror reflects most of the light falling on it.
- The angle of incidence equals the angle of reflection.
- A plane mirror produces a virtual image that is laterally inverted. The image is of the same size as the object.
- Laws of reflection in plane and spherical mirrors are the same.
- Spherical mirrors have a focal point.
- The image produced in a spherical mirror can be smaller or larger than or of the same size as the object.

### NOW ANSWER THESE

1. Explain how a periscope works.
2. Two plane mirrors are kept at  $90^\circ$  to each other as shown in Fig. 7.9. The incident beam AB is shown as falling on one of the mirrors PQ at an angle

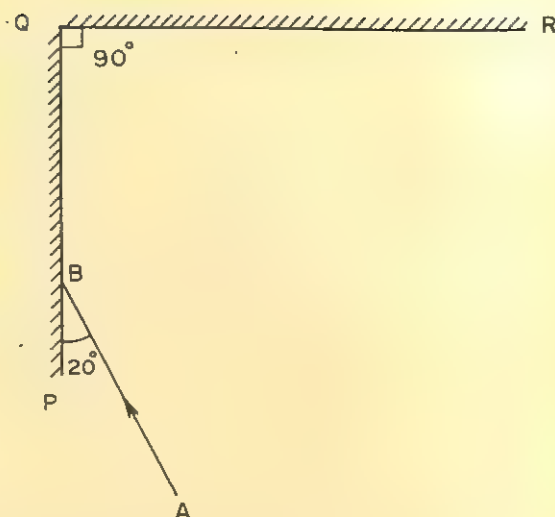


Fig. 7.9 Show the path of the reflected ray.

- of  $20^\circ$ . Draw the path of the ray and show the path of the reflected ray.
3. In the above arrangement, what will be the angle of reflection of the finally reflected ray if the angle ABP is 30 degrees?
4. Barber shops have two mirrors hanging on opposite walls facing each other. How many images of yourself can you see if you stand before them? Why?
5. What would happen to the rays falling on a concave mirror in Figure 7.7 if a small plane mirror is kept at F facing the mirror?
6. Does a convex mirror always give an image smaller in size than the object? Explain.

# Sound

WE HEAR MANY SOUNDS around us. We hear the sounds of our friends and parents talking, the sound of buses and cars running on the street, the chirping of the birds on the trees, the rustling of leaves in the breeze. In the monsoon, we hear the sound of rain falling on the roof and the sound of thunder. In the night, when most sounds cease, we can still hear the buzzing of a mosquito.

Each sound is special to the object producing it. Even machines produce their own special, or characteristic sound. The whirr of the ceiling fan and the ticking of a clock and the click of the electric switch are some examples.

We rarely forget a sound having heard it once, and quickly recognise it when we hear it again. Is this not like our ability to recognise the faces of our acquaintances, even when we meet them again after a long time? We might not be able to remember the precise words spoken to us by a person; but we do manage to remember certain qualities about the sounds of his or her voice.

What is this quality of sound that distinguishes one sound from the other? How is this sound produced? How is it heard? These are some of the questions

we shall try to understand in this chapter.

## 8.1 How Sound is Produced

### Activity 1

Fix a rubber band at one end and hold one end with your hand. Now pluck the rubber band and listen to the sound produced. Hear the sound produced as the rubber band is stretched. Does the sound change as you change the length of the band?

### Activity 2

Hold the flat of your palm gently against your throat. Recite the alphabets of any language you know or your favourite poem. Does your palm feel anything?

You will notice that in each case, sound is produced when the object performs a rapid to and fro motion. We call such to and fro motion—*vibration* or *oscillation*. In the first case the rubber band moves to and fro—that is, vibrates. You can also feel these vibrations if you hold your hand on the speaker of a transistor radio. In some cases, the vibrations are easily visible to our naked eyes but in some cases they are so small

that we feel them with our palms. The throat vibrates so little that we could only feel the vibrations. The vibrations of the rubber band were visible to our eyes. If we grab the band while it vibrates, its vibrations stop and so does the sound.

### Activity 3

Take a table tennis ball or a pith ball and suspend it from a height. Take a tuning fork, and hit its prong on the hard rubber pad. Hear the sound produced. Can you see the vibrations of the prongs of the fork? Now bring the vibrating fork close to the ball. What is the motion of the ball?

### ANSWER THESE

1. Which object is vibrating when the following sounds are produced?
  - (i) The sound of a sitar or veena.
  - (ii) The sound of the tabla.
  - (iii) The sound of a school bell.
  - (iv) The buzzing of a bee or a mosquito.
  - (v) The sound of a bursting balloon.
  - (vi) The radio.

## 8.2 Vibrations or Oscillations

We have seen that vibration is a repeated to and fro motion. This motion is also called an *oscillation*. Let us see a simple oscillation. Take a small pebble and tie it at the end of a string. Hang the string from a height as shown in Figure 8.1. Move the pebble to one side and release it. What motion does the pebble perform?

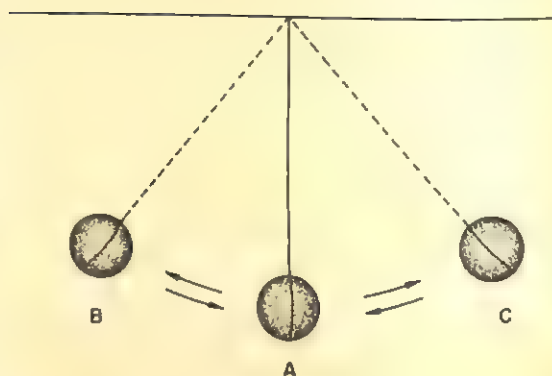


Fig. 8.1 *Vibration, Frequency and Time Period*

The stone moves from the right to the left and then back to the right. It does so repeatedly. After a while this motion stops and the pebble comes to rest. The motion is very much like the swing in a park. In the park you can either swing gently so that you do not go too far from the central position or you can give a large push so that you move far away from the central position.

Similarly the oscillations of the pebble can be large or small, depending on how high you lift the pebble before you release it. The distance to which the pebble goes from its central position has a special name. It is called the *amplitude* of the oscillation. We can increase the amplitude of oscillation by increasing the height from which the pebble is initially released. Similarly we can also decrease this amplitude by releasing the pebble from a smaller height.

When the pebble goes from one extreme position 'B' to the other extreme position 'C' and then back to 'B',

we say that it completes one oscillation. This oscillation took some time. The time taken to complete one oscillation is called the *time period*. Can you find the number of such oscillations in one second? You can easily do this if you count the number of oscillations in 60 seconds. This is the number of times the pebble goes from the left to the right and then back to the left in one minute. Dividing this number by 60 will give you the number of oscillations in one second.

The number of oscillations per second is called the *frequency* of the oscillation. Frequency is measured in *hertz*. If an object makes 10 oscillations in a second we say that the frequency is 10 hertz.

#### ANSWER THESE

1. The maximum displacement of an oscillating object is called the \_\_\_\_\_.
2. The number of oscillations made by the object is called the \_\_\_\_\_.
3. Pendulum A makes 14 oscillations in five seconds and pendulum B makes 10 oscillations in three seconds. Which has a higher frequency? Express the frequency of each pendulum in hertz.
4. The frequency of a vibration is the inverse of its time period. What is the period of a pendulum which is vibrating at 10 hertz?

### 8.3 Loudness and Pitch

Any vibration or oscillation has an

amplitude and a frequency. The amplitude tells us how far the object travels from its central position. The frequency tells us how fast it repeats its motion.

You have seen that sound is produced when objects vibrate. Due to vibrations of the object, the molecules of air close to the object also start vibrating with the same frequency. The motion of these molecules makes the molecules next to these move and so on. Soon all the air molecules in the vicinity begin to imitate the vibrating object and start oscillating. If our ear is in the vicinity of the vibrating air molecules, it feels the vibrations as *sound*.

The loudness of sound depends on the amplitude of vibration. When the amplitude of vibrating air molecules is large, we say that the sound is loud.

The frequency of vibration gives the sound its shrillness or pitch. If the frequency of vibration is high, we say that the sound has a high pitch. For example, the voice of a child or a woman has a higher frequency than the voice of a man.

In a table fan, you can hear the increase in the pitch of the sound as the fan increases its speed of rotation.

You must have seen a tabla or a *mridangam* player tighten the membrane of the instrument using a hammer or a stone. A tight membrane vibrates at a much higher frequency than a loose one, so that the sound produced has a higher pitch.

### Activity 4

As you stretched the rubber band in activity 1, the frequency of the vibration of the band changes. Listen to the sound produced in each case. How does the pitch of the sound change as you stretch the rubber band?

### Activity 5

Take a metal tumbler half filled with water. Tap the edge of the tumbler with a pencil and hear the sound produced. You can change the frequency of sound by filling it to different heights with water. Compare the sound in each case.

The Indian musical instrument called the *jal-tarang* shown in Figure 8.2, uses the principle you have learnt from this activity.

Fig. 8.2 *Jal-tarang*. The frequency in each cup is adjusted using appropriate amounts of water.



## MUSICAL INSTRUMENTS

Music is the arrangement of sounds of different frequencies called *notes* or *swara* in a way that is pleasant to hear. When we sing, we *modulate* our voice to produce these notes. With musical instruments, we use vibrating objects such as strings, skin and similar membranes, and columns of air in tubes or baffles. There are thus largely three families of musical instruments (i) string instruments (*tantu vadya*) such as the ones shown in Figure 8.3, where a string is stretched between two points and vibrates. Can you say how the frequencies or the notes are changed in say, the violin or the *sitar*? (ii) wind instruments or reed instruments (*sushir vadya*) such as the flute, the *shahnai* or the *nadaswaram* shown in Figure 8.4, where a column of air is vibrated. Air is blown directly or through reeds. Again, can you say how one changes notes here? (iii) membrane instrument (*avanaddha vadya*) of the kind shown in Figure 8.5. Many of these are percussion or rhythm instruments like the *tabla* or the *mridangam*.

In India, we also talk of a fourth class called *ghana vadya* which are simply beaten or struck. The *manjira* (cymbals), the *ghatam*

and the *noot* (mudpots), the *jaltarang* and bells are some examples.

Fig. 8.3 *Some string instruments—Sitar, Veena and Violin. Sound is produced by the vibration of stretched strings.*

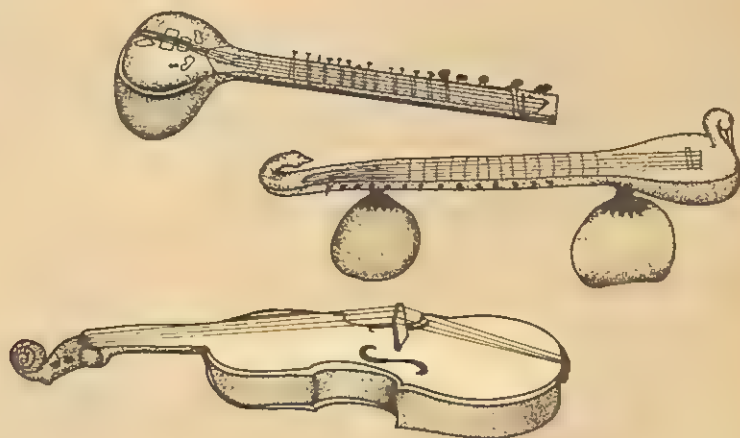


Fig. 8.4 *Some wind instruments—Shehnai and two Nadaswarams. Sound is produced by vibrating columns of air.*

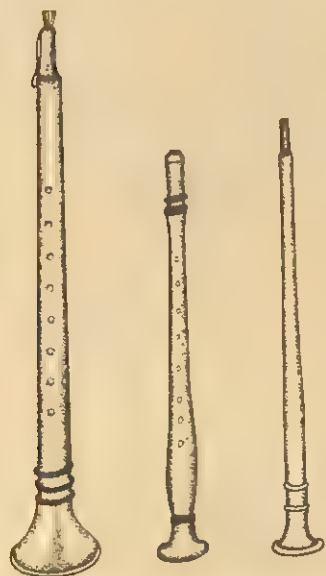


Fig. 8.5 *Membrane instruments used for rhythm—Mridangam and Tabla (a pair is used).*

### Activity 6

You can do this activity with your school iron bell or brass bell. If your school does not have one, visit a temple which has a brass bell. Hit the bell with the bell-hammer and hold the bell firmly with your palms. What happens to the sound? Why do you think it changes?

You would have noticed that the harder you tap the glass tumbler or the bell, the larger is the amplitude of vibration; and the louder is the sound. If you touch the tumbler or the bell the amplitude of vibration is reduced and the sound becomes less loud. When we walk on a carpet floor, the amplitude of vibration of the floor is greatly reduced and the sound of our steps is muffled.

Loud sound can cause great harm to our ears, and in some cases can even damage them permanently. Loud sound can even shatter a thin sheet of glass. If on the other hand the amplitude of vibration is small, our ears have difficulty in feeling these vibrations. We then say that the sound is feeble.

Just as our ears cannot hear the sound if the amplitude is too small, our ears do not respond if the frequency of oscillation is less than 20 hertz. Nor can our ears hear sound if its frequency is greater than 20,000 hertz. Sound of frequency greater than 20,000 hertz is called *ultrasonic* (ultra means greater and sonic refers to sound). The human voice can produce sounds with a frequency between 60 hertz and 13,000 hertz. This means we can hear sounds of

many more frequencies than we can produce.

Some animals like dogs, leopards, monkeys and deer can hear ultrasonic sound. Some animals can also produce ultrasonic sounds. The bat, for example, screams at a very high frequency much beyond the limit of our hearing.

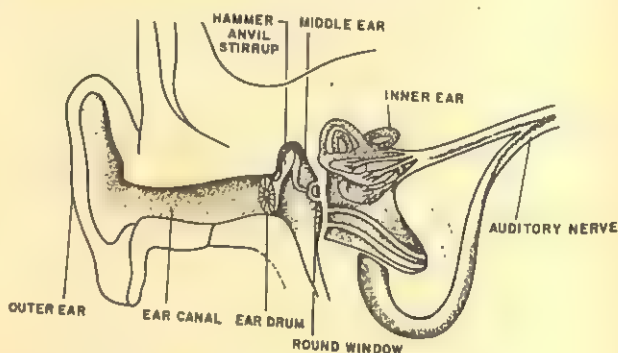


Fig. 8.6 Detailed structure of a human ear

The ears are the sensory organs that aid us in hearing. A cut view of human ear is shown in Figure 8.6. Sound from outside is collected by the outer ear and reaches the ear drum which is situated in the middle ear. When the sound strikes the ear drum, the drum vibrates to and fro. The nerve causes a delicate set of bones to move. The nerve connected to this region, called the *auditory nerve*, picks up this motion as a signal and sends it to the brain. Figure 8.7 shows how this transmission happens.

Our ears are delicate and fragile organs. We must take proper care of them. We should avoid putting anything inside the ear which will damage the drum. Damage of the drum can make a person deaf.

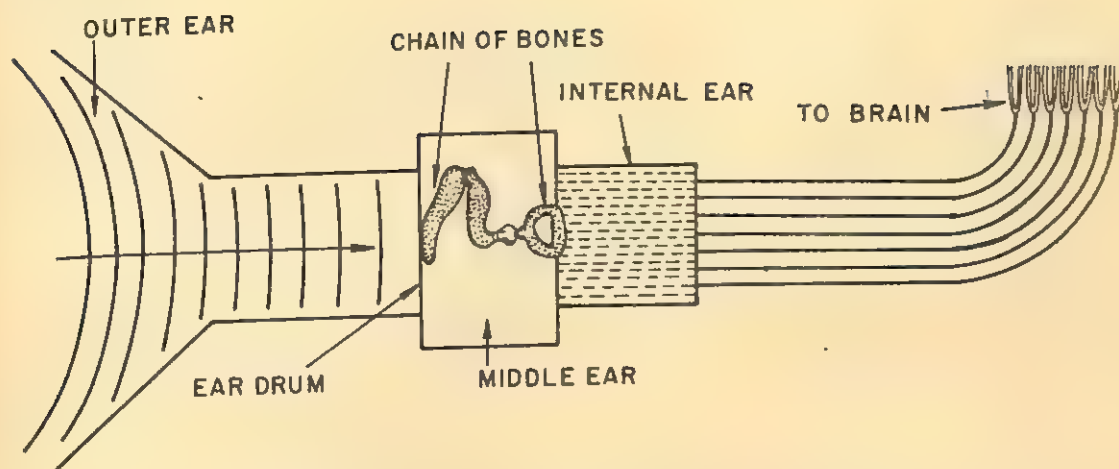


Fig. 8.7 Now sound is transmitted by the ear to the brain

- We have a drum inside our ear that vibrates when we hear sound. Its vibrations are passed on to the auditory nerve through very tiny bones.
- It is good that we cannot hear low frequency sound. Otherwise we would be disturbed by the noises produced by muscles and body movements.
- You can hear the contractions of your own muscles. How?

Stick a finger in each ear and lock it to outside sounds. You will hear a very low irregular tone produced by the contraction of muscles of your own arms and fingers.

- You could hear sound of 35000 hertz when you were one year old. As we age, our ability to hear high frequency sound comes down to the limit of 20,000 hertz.

#### ANSWER THESE

1. The loudness of sound is decided by the \_\_\_\_\_ of vibration.
2. The pitch or shrillness of the sound is decided by the \_\_\_\_\_ of vibration.
3. We hear sound only if its frequency is greater than \_\_\_\_\_ and lower than \_\_\_\_\_

4. A taut membrane produces sound of \_\_\_\_\_ frequency than a loose one.
5. Why do we not hear the screams of a bat.?

#### 8.4 Sound Needs a Medium to be Heard

We learnt earlier that when an object vibrates, it also makes the molecules of

air close to the object vibrate. These molecules make the molecules next to them vibrate. When these vibrations reach our ears we hear them as sound. If there is no air between the vibrating object and our ear we would not hear any sound at all. That is, *a medium is needed for sound to travel*. It can travel through any medium—solids, liquids, and gases, but not in vacuum. Let us do some activities in this connection.

#### Activity 7

Take a wooden stick and hold one end to your ear. Ask your friend to scratch or tap the other end gently. Can you hear the sound?

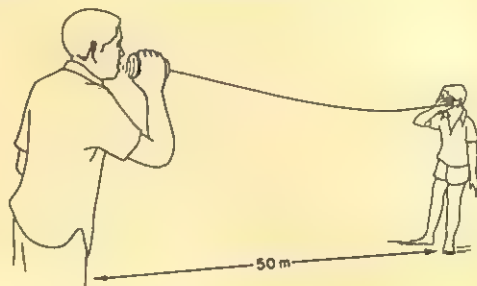
This activity shows that sound can travel through wood. Sound can travel through liquids also. You can check this

by filling a balloon with water. Hold the balloon close to your ear and rub the opposite surface. Can you hear the sound? Now do the same experiment with an air-filled balloon. You can compare the two situations.

#### Activity 8

Take two tin cans, each with a hole at the centre of the base. Through these holes

Fig. 8.8 A toy telephone



That sound needs a medium to propagate is forcefully brought out in outer space. For example, if one astronaut talked to another on the moon, he would see the lips moving but not hear any sound. The moon has no atmosphere at all. To communicate to each other the astronauts use another kind of vibrations which do not need a medium to propagate. These are called *radio waves*.

Some planets like Mars do have an atmosphere, but quite different from ours in design and composition. There, vibrating objects would be heard by our ears but the

quality of sound would be somewhat different.

Some years ago, we sent a spacecraft into deep space. It is called the *Voyager*. The voyager has carried a lot of information about our planet earth and its inhabitants. Should some alien civilization come across this information it would know that there are others and they are not alone. One of the contents of the voyager is a gramophone record containing the sounds of the earth—the sounds of birds, the sounds and the music of various countries, and the sound of the whales.

pass about 50 metres of thick threads, and fix a pin to each end, to hold the thread as in Figure. 8.8. You can now draw the tins apart so that the thread gets stretched and talk to your friend at the other end.

### VELOCITY OF SOUND

Sound takes some time to travel from the vibrating object to our ears. The speed of sound depends on the medium through which it travels. For example, in dry air the velocity of sound is 330 metres per second. Its velocity in water is five times higher, about 1.5 kilometres per second. That sound can be heard inside water and so rapidly is very important to the creatures in the sea. Whales actually sing to each other under water. Their frequencies overlap with human sound frequencies so that we can hear the whale songs quite easily. Thanks to the faster speed under water two whales hundred of kilometres from each other can talk to each other. The fact that the sound is not muffled or lost over this distance is also important in this matter.

### ANSWER THESE

1. Sound travels \_\_\_\_\_ in wood than in air.
2. If you want to hear a train approaching from far away, why is it more convenient to put the ears to the track?
3. One whale says something to its friend 75 km away. How long will it be before the friend can hear this?

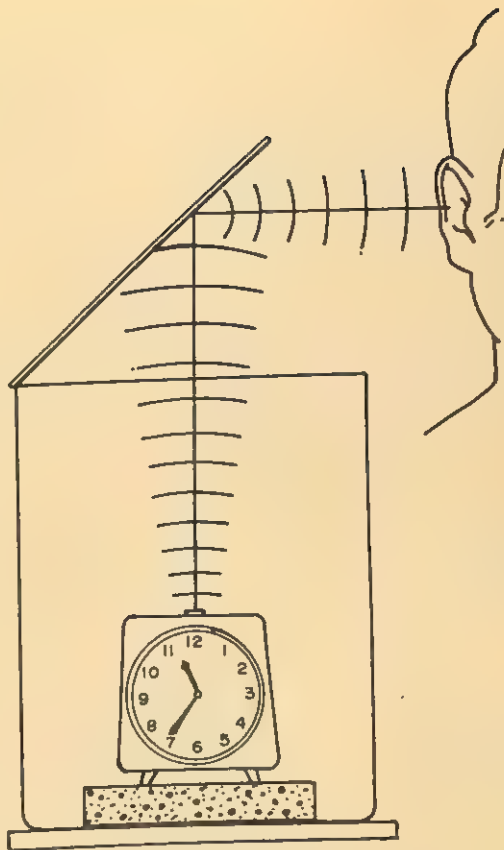


Fig. 8.9 Reflection of sound waves by the lid

## 8.5 Reflection of Sound

### Activity 9

Take a glass container and keep a ticking clock inside it as shown in Figure 8.9. When the mouth of the container is closed, the ticking of the clock is not heard distinctly. Now slowly lift the lid from one end. At a certain angle of lift, the ticking is heard most distinctly.

Sound, like light, can be made to change its direction. The lid reflected the sound and changed its direction and the ticking could be easily heard.

When a person speaks to us in a closed room the sound spreads in all directions. Some sound waves reach our ear directly, and some strike the walls. Some of those striking the walls get reflected and also reach our ears.

In a small room, the sound that reaches us directly and the one gets reflected from the walls reach our ears at about the same time. What will happen if there is a distinct interval between the two?

The human ear can hear two sounds separately and distinctly only if there is an interval of  $1/15$ th of a second between the two. If the two sounds reach our ears within an interval shorter than  $1/15$ th of a second we cannot distinguish between the two sounds. Since the speed of sound in air is about 330 m/sec, the distance travelled by sound in  $1/15$ th of a second is

$$\begin{aligned}\text{Distance} &= \text{speed} \times \text{time} \\ &= 330 \text{ metres/second} \times \\ &\quad 1/15 \text{ second} \\ &= 22 \text{ metres}\end{aligned}$$

Therefore, it is possible to hear the original and the reflected sound, if we are at a distance of 11 metres or more from

the reflecting surface. Then we hear the *echo* of the original sound. An echo is thus simply a reflected sound. The rules of sound reflection are quite the same as those of light reflection.

The reflection of sound is also used to measure the depth of the ocean floor. A short sound signal is sent from the ship to the bottom of the sea. After reflection from the ocean floor, the signal returns to the ship. Knowing the speed of sound in sea water, and the time taken by the signal to go to the bottom and return, we can easily determine the depth of the ocean.

Sound is not reflected equally from different materials. Metallic sheets and plywood are good reflectors of sound. Clothing and porous materials like cork or thermocole are bad reflectors. They absorb most of the sound striking them. The walls, ceiling and floor of a good auditorium or cinema hall are covered with such absorbing materials. This reduces the reflection of sound and the audience hears only the sound coming from the source and is not disturbed by echoes.

Bats use the sound reflected from obstacles to avoid them. They emit high frequency squeaks and listen to the echo produced from obstacles in their path. The time it takes for the echo to return gives them an estimate of the distance of the reflecting source.

There are amongst us some brothers and sisters who cannot hear. They are deaf. They do not hear any of the wonderful sounds which give us such great pleasure. There is no mother's lullaby to put them to sleep, and no chirping birds to wake them up. For them it is only a long and deep silence. Some of them who are deaf since their birth have heard no speech and, therefore, cannot learn to speak. They are called the deaf-mute. Even with this great disability, some of them learn to

lead a full and satisfied life. They communicate by making signs with their fingers. This sign language is very easy to learn and use and is taught in speech schools for them.

*Helen Keller*, one of the most courageous of the disabled (she was also blind) even taught herself to listen to music by feeling the vocal chords of the singer.

Try and visit one such school nearby for the deaf-mute. Share their joys, and yes, their sorrows too.

## THE SOUNDS OF MUSIC

Regular vibrations produce musical sounds. Irregular vibrations are annoying and are called *noise*. In music, we talk of a *scale* or the musical notes produced by an instrument. Eight notes make up an *octave*, in the order—upwards as:

*Sa re ga ma pa dha ni Sa*  
and

*Sa ni dha pa ma ga re Sa*  
downwards. In Europe the notes are:

*Do re mi fa so la ti Do*

*Do ti la so fa mi re Do*

(and the scale is C D E F G A B C')  
The first (Sa), fifth (pa) and the

eighth (Sa) notes of an octave are related in their sound frequency. The eighth note (Sa) has always twice the frequency of the first (Sa). The fifth (pa) always has a frequency that is one and a half times that of the first (Sa).

The entire octave is built on such relations. To produce harmonious sounds, we do not use any frequency range. Instead, we use a tempered scale of 13 notes in the octave. These use two *re* (flat and natural), two *ga* two *ma*, one *pa*, two *dha* and two *ni* besides the lower and the upper *Sa*. These are the *swaras* of our music.

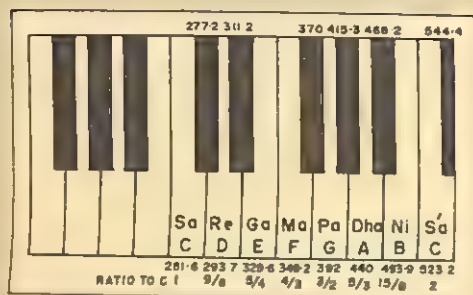


Fig. 8.10

Part of the keyboard of a piano (or a harmonium)

Figure 8.10 shows a harmonium or a piano keyboard with all the notes of the octaves and their frequencies in hertz. Notice that the notes have definite relationship; this is what produces a pleasing or a harmonious effect. Sounds produced by various musical instruments have different qualities. The sound of a violin can be distinguished from that of a flute, even if the two play the same note of the same pitch and

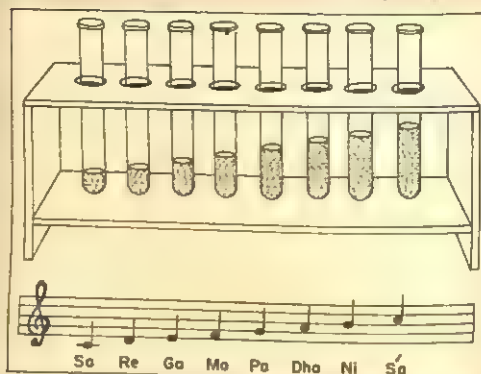


Fig. 8.11

Music with test tubes. Is this a wind instrument or a jal-tarang?

loudness. This difference is called *timbre* or quality. In an orchestra, instruments of different timbre are used in a pleasing fashion.

To show how a musical scale is produced, you can set up eight test tubes as shown in Figure 8.11 and fill them to proper levels and blow air across the tops of the tubes. You can tune them by adding appropriate amounts of water in each.

### ANSWER THESE

1. What is the minimum distance required to produce a distinct echo?
2. Which of the following materials will give a good echo and which would stifle or muffle sound falling on them?

(i) Wood

- (ii) Steel
  - (iii) Asbestos
  - (iv) Paper
  - (v) Thermocole
3. The speed of sound in water is 1500 metres per second. How far away from an under-sea rock, should a deep sea diver be, so that he can hear his own echo?

## YOU NOW KNOW

- Sound is produced when objects vibrate.
- The larger the amplitude of vibration, the louder is the sound.
- The higher the frequency of vibration, the higher the pitch.
- Human ear can only hear sounds of frequency between 20 hertz and 20,000 hertz.
- Some animals can hear sounds of frequency higher than 20,000 hertz.
- Sound needs a medium to be propagated. It cannot travel in a vacuum.
- Sound can be reflected.
- Some surfaces reflect sound better than others. Metals and other hard surfaces reflect better than thermocole or wood.
- Human ear can distinguish two

sounds only if the time interval between them is greater than  $1/15$ th of a second.

## NOW ANSWER THESE

1. Where would sound travel faster? In wood or in water?
2. List some oscillations which you see around you. Do all of these produce sound?
3. Arrange the following sounds in increasing frequency.  
(i) Baby's voice (ii) Man's voice. (iii) Woman's voice.
4. Why do we hear more clearly in a curtained room than in a room without curtains?
5. The deepest part of the oceans in our world is the Mariana Trench in the Pacific ocean, and is 11,033 metres deep. If you were on a ship above this trench and send a sound signal straight down to the water, how long will it take for the echo to reach you?

## CHAPTER NINE

### Electric Charges at Rest

WHAT HAPPENS when a plastic comb is rubbed with a silk cloth or paper? You will notice that it starts attracting tiny bits of paper. We then say that the comb is charged with electricity. Such an observation was first made by a Greek man named *Thales* over 2500 years ago. Thales did not use a plastic comb but a material called amber. He found that amber attracted tiny feathers after it was rubbed with silk. This property was called electricity. The word electricity comes from the term *elektron* that means amber in the Greek language. Let us learn a little more about electricity in this chapter.

#### 9.1 Positive and Negative charges

##### Activity 1

Blow up a balloon and tie it up. Rub the balloon against your dry hair 10-12 times. Now place it gently against the wall. What do you see?

The balloon sticks to the wall because it is charged. You charged it by rubbing it against your hair. The charged balloon attracts the wall and holds on to it. This is quite like charging a comb and letting it attract tiny bits of paper.

Can all bodies be charged in this manner? And will they be charged to the same extent? We can test this in several ways.

##### Activity 2

Take an ebonite rod or a plastic ruler (scale) and rub it with wool or flannel. Now suspend the rod by tying a thread through its middle as shown in Figure 9.1.

Now charge another ebonite rod or plastic scale in the same way and bring it close to the suspended rod. What do you observe? The suspended rod moves away from the second one. The two charged rods are not attracted, but *repelled* by each other.

Now take a glass rod or a test tube. Charge it by rubbing it with silk. Bring the charged glass rod close to the charged suspended ebonite rod or scale. What do you observe now? The suspended ebonite rod moves towards the glass rod. This is the opposite of what happened between the two ebonite or plastic rods.

The ebonite rods, when charged in the same way, repel each other. But the ebonite rod charged by rubbing with

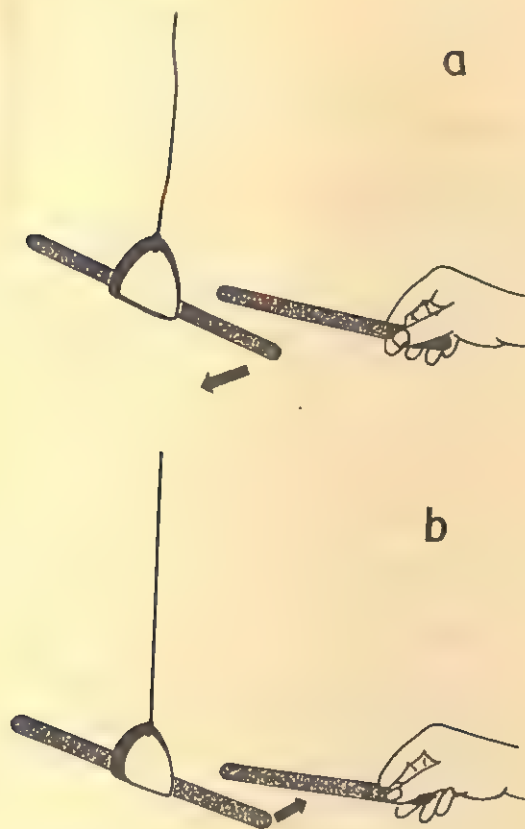


Fig. 9.1 (a) Set-up of the experiment to find out how two electrified rods interact  
(b) Set-up of the experiment to find out how electrified ebonite rod and glass rod interact

wool attracts the glass which is charged by rubbing with silk. The charge produced in the ebonite is different from the charge produced in the glass.

These two kinds of charges are called *positive* and *negative* charges. The positive charge is represented by the + sign and the negative by the - sign. As a convention, scientists have agreed to call the electric charge on a glass rod

rubbed with silk as *positive*. The charge of an ebonite rod rubbed with wool is taken as *negative*. When other substances are rubbed in a similar way it is found that some are charged positively and some others get charged negatively.

From the above experiment, we see that two negative charges repel each other; and a negative charge and a positive charge attract each other. How will two positive charges interact? To see this, let us charge two glass rods or tubes by rubbing them with silk. Now if we suspend one of them and bring the other near it, we would see that the two rods or tubes repel each other, just as the two ebonite rods did.

Thus we may conclude that *like charges repel each other* and *unlike charges attract each other*.

### Activity 3

Let us now take a plastic scale, one side of which is lined or covered with flannel. Rub this side of the scale with another simple plastic scale, as shown in Figure 9.2 (a). Now test each scale separately to see if it can attract tiny bits of paper. We thus charged the two scales by rubbing one against the other. Now, suspend one of these rods with a thread and bring the other close to it. What do you see? The two attract each other!

When we rub two bodies together, both of them get charged, but with opposite charges.

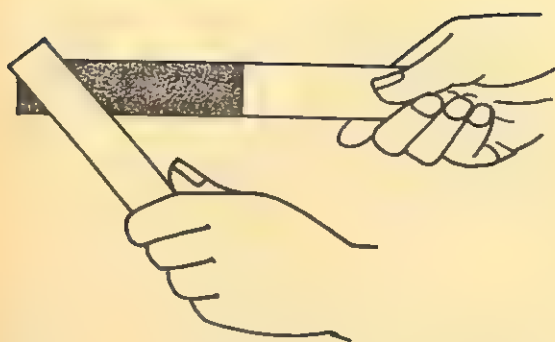


Fig. 9.2 (a) Two bodies being rubbed together for charge

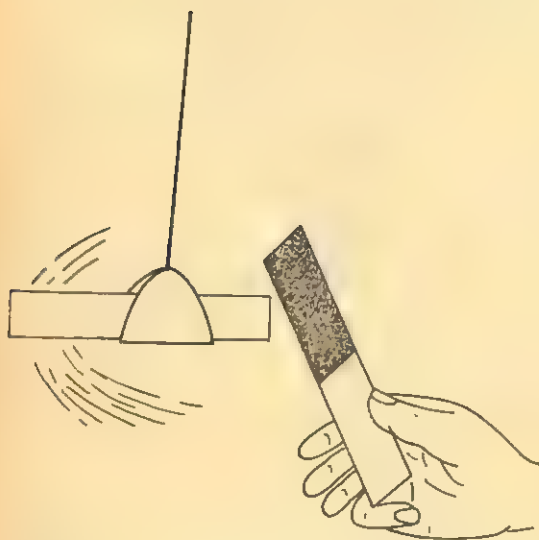


Fig. 9.2 (b) Two rubbed bodies attract each other here.

#### ANSWER THESE

1. An ebonite rod when rubbed with wool, becomes \_\_\_\_\_ charged.
2. A glass rod, when rubbed with silk, becomes \_\_\_\_\_ charged.
3. Two ebonite rods rubbed with wool \_\_\_\_\_ each other.
4. An ebonite rod rubbed with wool \_\_\_\_\_ a glass rod rubbed with silk.

5. Two objects rubbed against each other will \_\_\_\_\_ each other.

#### 9.2 Charging by Contact and the Electroscope

We have seen that an object can be charged by rubbing it with silk or wool. But is this the only way to charge a body? To answer this question let us do another activity.

##### Activity 4

Take a sheet of paper and roll it into a hollow cylinder. Tie up one end of the cylinder with a silk thread and hang it from a stand. Now take an ebonite rod and charge by rubbing it with wool. This ebonite rod will be negatively charged. Now bring this charged ebonite rod near the paper cylinder. The cylinder will be attracted to the rod.

Now touch the cylinder with the charged rod. When you do so, you will see that the cylinder is *repelling* the rod (as in Fig. 9.3)! This would mean that

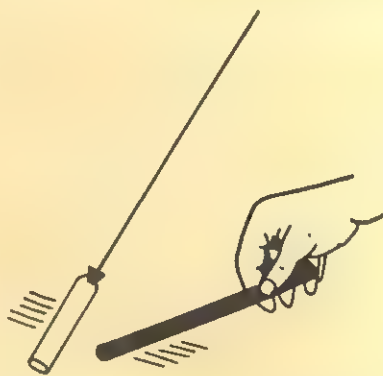


Fig. 9.3 After being charged the paper cylinder repels the ebonite rod.

the rod has passed on some of its negative charge to the paper and hence the two repel each other.

We can thus also charge one object by bringing it in contact with a charged body. Is the paper cylinder in the above activity charged? Yes. You can satisfy yourself by checking if it attracts tiny bits of paper to it now. Detection of this charge by contact can be done better with the following activity.

#### Activity 5

Take a thin strip of paper 1 cm × 5 cm. Fold it in the middle and mount it on a stand using a wire hook as shown in Figure 9.4. The two parts of the folded strips are close to each other. Bring a charged ebonite rod close to the paper strip. You will see that it attracts the paper strip. Now touch one side of the paper strip with the charged rod. When you do so, you will see that the paper strip opens up. The two sides of the strip get away from each other, or diverge (Fig. 9.4).

Why did the paper strip open up or diverge when touched with a charged rod? By contacting it with a charged rod, we charged the two folds of the paper with the same kind of charge. Since like charges repel (+ and + or - and -) each other, the two like-charged folds repelled and diverged.

The *electroscope* is a device which works on the same principle. It is shown in Fig. 9.5. A metal rod has a thin metal strip or leaf attached to it at the bottom.

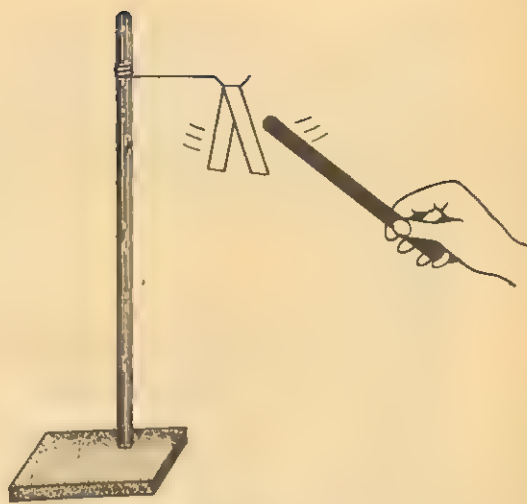


Fig. 9.4 The principle of action of an electroscope

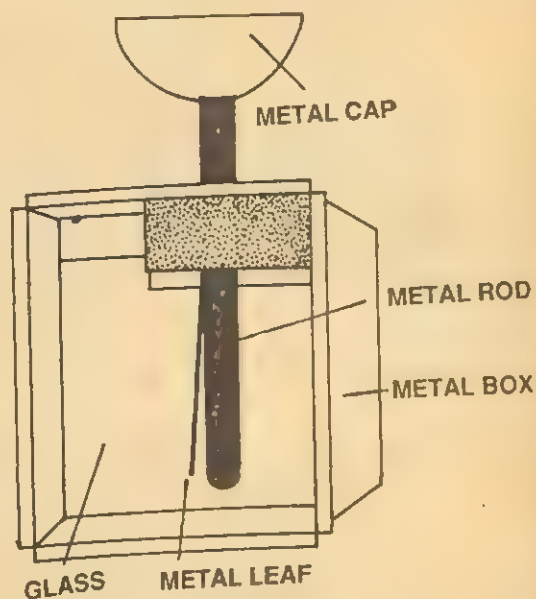


Fig. 9.5 A simple electroscope

At the top, the rod ends in a cup. The metal strip can be of copper, brass or gold. The bottom part of the rod and the leaf are enclosed in a glass box for

protection. When we touch the cup of the electroscope with a charged body, say an ebonite or glass rod, the leaf will open out or diverge. The more the charge on the glass rod, the greater will be the divergence of the leaf.

### ANSWER THESE

1. Why does the paper cylinder initially attract and then later repel when contacted with the ebonite rod?
2. Is this initial attraction similar to the attraction between the balloon and the wall in the first activity?

### 9.3 Making Charges Flow

Take two electroscopes and keep them side by side. Charge one electroscope by touching its cup with a charged ebonite rod. Its leaf will now spread or open out. Take a wire of copper or aluminium and place it in contact with the two cups of both the electroscopes. When you do this, the leaf of the second electroscope also opens out (Figure 9.6 a). You have made the charge flow from the charged electroscope to the uncharged electroscope.

Now repeat this experiment using a plastic thread or comb in place of the metal wire. What do you observe? The leaf of the uncharged electroscope does not open up (Figure 9.6 b). Plastic is not able to let the charge flow from one electroscope to the other as metal could

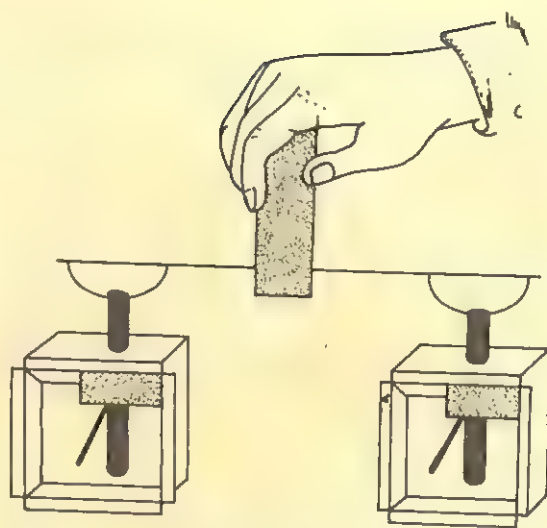


Fig. 9.6 (a) Magnet charges flow from one electroscope to another.

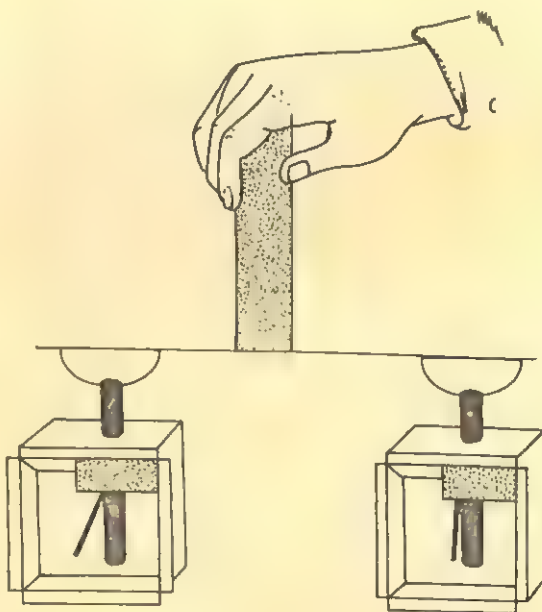


Fig. 9.6 (b) When a plastic rod is used instead of a metal wire, it does not transfer charge from one electroscope into another.

Materials differ in their ability to transfer or *conduct* electric charges. Though plastic could be charged, it could

not conduct the charge between the two electroscopes. You can induce electric charge in plastic, but plastic fails to *conduct* electricity. The ability of a material to conduct electricity depends on the nature of the material. Metals are excellent conductors. Non-metals like wood, charcoal, phosphorus or chlorine oxygen or hydrogen are poor conductors. These are called *insulators*. Plastic is an insulator. Our body is a conductor of electricity. You can easily test this by charging an electroscope first and then touching the cup. When you do so, the charge is transferred to your body from the electroscope. Its leaf will fold up! Rubber is a bad conductor or an insulator. A rubber balloon can be charged as in Activity 1, but rubber bands cannot conduct electricity from one electroscope to another. It is for this reason that stored up charge is called *static* electric charge. The word *static* means not moving. Conduction of electric charge means transferring it from one place to another. When this is done, we talk of an electric current flowing from one place to another.

#### ANSWER THESE

1. What are insulators? Give three examples.
2. What is static electricity and what is an electric current?
3. What will happen to a charged electroscope when you touch its cup? Why?

### 9.4 Electricity in the Sky

Large amounts of electric charges are built up in the clouds in the sky before a thunderstorm. What can happen when two clouds with unlike charges approach each other? Charges can start moving with high speed through the air in between. When this happens, lightning strikes and we see the intense spark of electricity travelling in the air. This is called the electric discharge or lightning.

Sometimes when the wind direction changes, the clouds move and charges in the cloud can be discharged into the earth. When this happens, we say that lightning has struck on earth. Figure 9.7 shows a view of such a lightning between the clouds and earth.

When this electricity is discharged through a tree or a building, it can set them on fire. You should not stand under a tree during a thunderstorm. This is because of the danger of the lightning



Fig. 9.7 Lightning strikes

discharging through the tree or even through the human body.

That lightning is electric in nature was shown first by the American scientist *Benjamin Franklin* (born in 1706 and died in 1790). He did this dramatically by flying a kite. He hung a metallic key from a kite and flew the kite into the clouds. When lightning struck, the key was found to be heated and electrically charged. Franklin pointed out that he drew out the electricity from the cloud into the key. The huge energy released during the brief discharge heated the key.

Franklin went further and said that this can be put to practical use. He suggested that every building should have a metal wire or rod buried in the ground at one end and with a needle-like tip pointing at the sky at the other end. If lightning strikes the building, this metal would discharge it and send it harmlessly to the ground. You can see such *lightning conductors* in many tall buildings.

Franklin was a remarkable man who invented many useful things. He was the man who first did the experiment on spreading oil on water that you read about in chapter one. He was also the one who invented the bifocal spectacles and reading glasses that many of us use in order to see better.

## YOU NOW KNOW

- Rubbing objects with silk, wool or hair charges them electrically.
- There are two types of charges, positive (+) and negative (-).
- Charges always occur together as pairs of + and -, and never alone.
- Non-metals and organic compounds are insulators.
- Charges can be transferred from one place to another. This flow of charges is called *electric current*.
- When charged clouds collide and discharge, lightning occurs.
- Lightning is an electric discharge in the sky.
- Lightning can be discharged harmlessly into the ground through lightning conductors.

## NOW ANSWER THESE

1. Why does a rubber balloon, after being rubbed, stick on to a wall?
2. Do all bodies get charged after being rubbed?
3. Why does the paper strip open up when touched with a charged rod?
4. How can we make electric charges flow?
5. How does a lightning conductor work?

## Energy

WE DO WORK whenever we move an object. We may lift an object and keep it at some other place. We may push it from one place to another. Both involve a change in position. Sometimes we change the shape of an object. For example, we knead the dough, or squeeze a tomato. This involves work. The ability to do work is known as *energy*. Energy is spent when an object does work. We know that there are different forms of energy such as heat energy, light energy, sound and electrical energy. They are all capable of doing work. For example, the heat energy in a steam engine moves the piston which drives the wheels of a train, loud sound is capable of shattering glass and throwing the small pieces to large distances. Electrical energy is used to turn the blades of a fan. In this chapter we shall see some forms of energy and how one form of energy is converted to another.

### 10.1 Mechanical Energy

When a moving cricket ball hits the stumps it displaces them. In a game of marbles, a moving marble can displace a marble at rest. If a moving car hits a bicycle, it often twists and deforms the

bicycle. In a river, the moving water rolls the stones, making them smooth and round. You see in these examples that a moving object displaces or deforms another object. Therefore, a moving object has energy. The energy possessed by an object due to its motion is called *kinetic energy*. The word *kinesis* in Greek means *motion*.

An object raised to a height can also do work when it falls. For example, we could use the falling object to crush other objects. Similarly, a compressed spring can move objects as it expands. In a clock, the spring is wound so that it moves the hands of the clock as it unwinds. In a catapult, the stretched rubber strip throws the pebble held in it. The raised hammer, stretched rubber, or compressed spring are capable of doing work because of the energy stored in their position or shape. The ability of an object to do work due to its position or shape is called *potential energy*.

You must have lighted firecrackers. The firecracker has carbon, sulphur and potassium nitrate in it. When you light the cracker it explodes giving a flash of light and a loud sound. The firecracker has potential energy stored in the

molecules of the chemicals. Similarly the food eaten by animals is digested and utilised to provide the energy required by the body. Fuels such as cowdung cakes, fuelwood, coal, kerosene and cooking gas have potential energy stored in them. This energy is released by burning them. The energy stored in molecules is a form of potential energy, also known as *chemical energy*.

Kinetic energy and potential energy are examples of two types of energy together known as *mechanical energy*. The total mechanical energy possessed by an object is made up of its potential and kinetic energy.

A piece of rock standing at the top of a hill has no kinetic energy, but only potential energy. Its mechanical energy is thus equal to its potential energy alone. When this rock starts rolling downhill it has both kinetic and

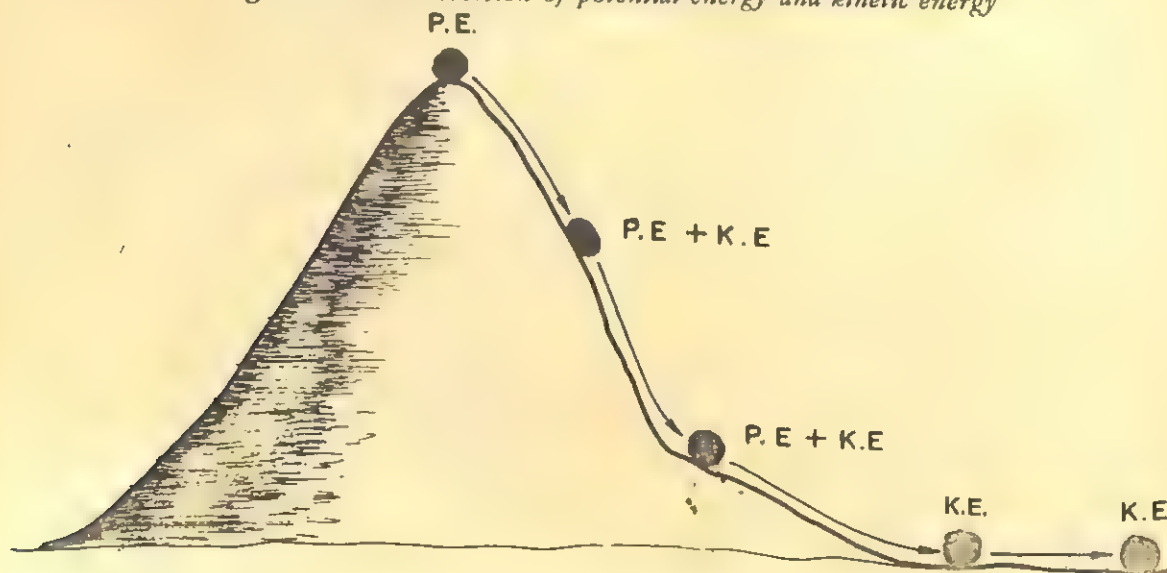
potential energy. The mechanical energy of this rolling rock is equal to the sum of its potential and kinetic energy.

When a marble is rolled on a flat surface its potential energy does not change (Figure 10.1). The mechanical energy of the marble is equal to its kinetic energy.

#### ANSWER THESE

1. Distinguish between kinetic energy and potential energy.
2. Give three examples of potential energy.
3. Give an example where the mechanical energy is the same as potential energy.
4. Describe the mechanical energy possessed by you as you go down a slide or ride a swing (*jhoola*) (*oonjal*).

Fig. 10.1 Interconversion of potential energy and kinetic energy



5. Fill in the blanks

- (i) The water stored in an overhead tank possesses \_\_\_\_\_ energy.
- (ii) An aeroplane flying in the sky possesses \_\_\_\_\_ and \_\_\_\_\_ energy.
- (iii) Chemical energy is a form of \_\_\_\_\_ energy.
- (iv) While rolling a chapati, \_\_\_\_\_ energy of the rolling pin is used to do the work.

### 10.2 Transformation of Energy

We need different kinds of energy for doing different kinds of work. For heating milk we need heat energy. This heat energy can be obtained from different sources: by burning a fuel, or from an electrical hot plate. For stitching clothes a sewing machine is used. It needs mechanical energy to run. The machine can be run with a hand or foot or an electric motor. Electrical energy can be obtained from the power line, a battery cell or from a generator. These examples show that the same type of work can be done by using different sources of energy. Energy can be converted from one form to another. Such conversion is known as *transformation of energy*.

In Chapter 9, we saw how rubbing the balloon gave it electrical energy. In Chapter 8, we saw that vibrations of objects lead to sound energy. And heat is largely the kinetic energy of motion of molecules. However, in Activity 7 of Chapter 4, we studied about the latent

heat of melting of ice (water). The latent heat is a form of potential energy (chemical energy).

Let us take another example. The water in an overhead tank possesses potential energy. When it flows through a pipe it also possesses kinetic energy. This flowing water can run a dynamo and produce electrical energy. Water stored in reservoirs produces electricity in hydroelectric power stations in a similar way. The energy transformation is as follows:

Water in the reservoir  $\rightarrow$  Flowing Water  $\rightarrow$   
Potential energy  $\rightarrow$  Kinetic energy

Generator  $\leftarrow$  Moving turbine  $\leftarrow$   
Electrical energy  $\leftarrow$  Mechanical energy

Take another example of a bicycle dynamo used for lighting the bicycle lamp. How does it do so? The steps in the transformation are:

Chemical energy of the muscles of the rider  $\rightarrow$  Mechanical energy (pedals)

Mechanical energy (dynamo)  $\leftarrow$  Mechanical energy (wheels)

Electrical Energy (dynamo)  $\rightarrow$  Heat energy (bulb filament)

Light

In this interconversion, sound is also produced. In addition, the axle of the wheels and the dynamo can get heated up due to the transformation of some mechanical energy into heat. Whenever mechanical energy is transformed, some heat energy is always produced because of friction. This is why machines are *lubricated* so as to reduce the wear and tear and the heat of friction.

What happens in an electric fan? Here, electrical energy is transformed into mechanical energy. The fan blades rotate and move the air. When an electric heater or bulb is switched on, electrical energy is transformed into heat energy. The heater or the bulb filament becomes hot and gives out light. When we ring an electric bell, sound is produced. See how convenient it is to transform electrical energy into several other forms of energy—mechanical, heat, light and sound.

We thus see that it is possible to convert one form of energy into any other form. Which form to start with is a matter of convenience and efficiency.

There is an important principle that can be learnt from the transformation. Let us look at the pendulum in Figure 8.1 of Chapter 8. When it is oscillating in position A, it has minimum potential energy. The pendulum has maximum kinetic energy in this position. As it moves to the side it loses kinetic energy and gains potential energy. At positions B and C, it has no kinetic energy and maximum potential energy.

The example of the pendulum shows that potential energy is transformed into kinetic energy. This kinetic energy is then converted back into potential energy. The total energy, potential plus kinetic stays constant. In other words energy is *conserved* during the transformation. This means that during transformation, the total amount of energy remains the same. This is known as the *principle of conservation of energy*.

#### ANSWER THESE

1. Describe the mode of energy transformation in a mechanical and an electrical clock.
2. How can light energy be converted into mechanical energy?
3. Fill in the blanks
  - (i) Sun's radiation heats the earth. The air in turn is heated by land and rises up. In this case \_\_\_\_\_ energy is transformed into \_\_\_\_\_ energy.
  - (ii) In a photoelectric cell, \_\_\_\_\_ energy is converted into \_\_\_\_\_ energy.
  - (iii) In a cinema theatre electrical energy is transformed into \_\_\_\_\_ and \_\_\_\_\_ energy.
4. List three sources of energy seen in your home.

#### 10.3 Judicious Use of Energy

For each of his activities, man uses one source of energy or the other. Energy

from the sun is used in agriculture. Energy from coal, wood, kerosene and diesel is used at home, in factories, and for driving pumps and vehicles. Electricity is generated by transforming other sources of energy such as the potential energy of water or the chemical energy of kerosene, diesel, or coal.

What are the sources we get our energy from? Wood, animal waste, coal and petroleum are some chemical sources that we use directly or indirectly. For example, we use petroleum products like diesel as fuel to run buses or to generate electricity which is then used elsewhere. Petroleum and coal are sources of energy that are obtained from the earth. And the energy resources on earth are limited. Yet, we are using up more and more of these resources. The population has grown, our needs have grown but the sources of energy are not growing—they are, in fact, decreasing.

Let us see how our need for energy has grown recently. Our population has increased enormously in the last 40 years. And many more people have come and settled in towns and cities. A man in the city uses much more energy than his brother in the village. The city dweller uses transport like buses, cars and scooters that use petrol and diesel. He uses more electricity, his house is constructed from materials that need a lot of energy to produce—such as steel, cement, aluminium and rubber. You can now see how much our demand for energy has increased suddenly. All the

energy has to come from materials on earth or from the sun.

Out of the various sources of energy, some are *renewable sources*. That is, these are available continuously or can be renewed at short intervals of time. Wood, water, wind, animal wastes and the sun light are examples of *renewable sources of energy*. If a forest is cut for firewood or other needs, it can be (and should be) regrown in some years or renewed. On the other hand, some other sources of energy have taken a very long time to form. Coal that we use as an energy source, was formed by the very slow decaying of trees and forests over a period of millions of years. The total amount of coal supplies in the world today is limited. If we use up all this coal rapidly, we will have no coal left in a short while. No new supplies of coal will be available since it takes an enormously long time for nature to make coal or to renew our coal supply. The story of petroleum, the other popular source of energy, is also the same. It has taken millions of years to form petroleum and the total supply of this fuel is limited. To renew its supply will take a long long time. Coal and petroleum are examples of *non-renewable sources of energy*.

With increasing use of energy, we are depleting the reserve supplies of coal and petroleum. We are already in such a critical stage that we may have no coal or petroleum at all left for use in about 100 years or so! We, therefore, need to use our energy sources wisely and

economically—and conserve as much of our energy resources as we can.

How can we do this? Firstly, *we must reduce our dependence on non-renewable resources*. For example, can we design or invent vehicles that do not use petrol or diesel as fuel, but electricity or sunlight? If we can, then we reduce our consumption of petroleum. Many scientists and engineers are working on this idea. Or, can we use water and wind power, rather than diesel or petrol or coal power, to generate electricity?

Secondly, *we must look for and use alternative fuels and sources*. Rather than using coal, kerosene or cooking gas, can we use animal wastes or plant wastes at home, the community and the factory? We have now learnt to extract energy from animal wastes such as cowdung or plant wastes like sugarcane bagasse. One successful method is to ferment animal wastes in closed vessels and produce a gas called *biogas*, which is just as good as cooking gas. The waste from the biogas plant can be used as manure in fields and plantations. A second example is the use of windmills, where wind is used to turn a paddle wheel and to produce electricity or to lift water.

Thirdly, *we must make greater and cleverer use of the sun*. The sun is a perennial source of light and heat for the earth, and it is free! If we could devise methods for capturing the heat and/or light from the sun and transforming it into electricity, we would greatly benefit.

Energy is like money!. Just as energy is the ability to do work, money has the ability to buy things. When we have money we can buy the things we want. Just like energy, money too comes in various forms. We have the Indian Rupee, the American Dollar, the British Pound or the German Mark. We can also convert one form of money into another. For example we can get one American Dollar for about 13 Indian Rupees or we could convert one British Pound to one and a half American Dollars.

When we receive a fixed amount of money every month, we plan our budget so that it meets our daily needs. Spending money indiscriminately could lead to problems at the end of the month. The same is the case with energy. The energy resources on earth are limited. If we spend them off indiscriminately we are bound to have problems in a short time. Just as we bargain and save a part of our earnings, we must plan the utilisation of our non-renewable resource!

Devices that do this conversion, called *solar cells*, are already available and will become very important very soon. Solar water heaters, solar cookers and solar dryers are also available now, which focus and concentrate the heat (and the light) of the sun into small areas where the heating is efficiently done.

In fact, think about what plants do with the sun and with the environment around them. A forest is a great factory where the individual machines, the plants and the trees, silently collect the energy of the sun and transform it into useful products. If only we could learn the actual mechanism by which they do this and copy it, we would be able to solve our energy problems!

#### ANSWER THESE

1. What are renewable and non-renewable sources of energy?
2. Give two examples each of renewable and non-renewable sources of energy.
3. Why should we increase the use of renewable source of energy?
4. Name some devices that utilise solar energy?
5. Fill in the blanks
  - (i) The water stored in a dam is a source of \_\_\_\_\_ energy.
  - (ii) Three examples of renewable sources of energy are \_\_\_\_\_ and \_\_\_\_\_.
  - (iii) \_\_\_\_\_ and \_\_\_\_\_ are non-renewable source of energy.

- (iv) People living in \_\_\_\_\_ use more energy than people living in \_\_\_\_\_

#### YOU NOW KNOW

- A moving object possesses kinetic energy.
- Mechanical energy of an object is made up of its potential and kinetic energy.
- Chemical energy of molecules is a form of potential energy.
- Energy is neither created nor destroyed. It is only transformed from one type of energy into another.
- During the transformation of energy, work is done.
- Energy sources are of two types—renewable and non-renewable.
- As far as possible renewable energy sources should be utilised. The non-renewable energy sources should be conserved.

#### NOW ANSWER THESE

1. A rubber ball is dropped from your hand. Describe the mechanical energy of the ball.
2. Fill in the blanks.
  - (i) When you climb a tree, you use \_\_\_\_\_ up \_\_\_\_\_ energy and gain \_\_\_\_\_

- (ii) When an athlete runs, \_\_\_\_\_ source and gives \_\_\_\_\_  
energy is changed into \_\_\_\_\_  
energy. and \_\_\_\_\_ for use.
- (iii) A biogas plant uses — as the
3. Why is the transformation of energy useful?



## CHAPTER ELEVEN

### Water

WATER HAS some very interesting properties that make it a special substance. It is a stable substance. Solid water or ice is lighter than liquid water. Water has a high heat capacity and conducts heat badly. It dissolves almost any substance. Some of these properties make water the *essence of life*. Unfortunately, water can be easily polluted and made harmful to our health. We will study many of these aspects of water in this chapter.

#### 11.1 The Water Molecule is $H_2O$

Water is a stable substance. Boiling produces steam which, on cooling, gives back water. In fact, one has to heat water to beyond  $500^{\circ}C$  in order to break the molecules of water into  $H_2$  and  $O_2$ . Alternatively, we can pass an electric current through water. This method of using electricity to break down molecules is called *electrolysis*.

#### TEACHER DEMONSTRATION

##### *Electrolysis of Water*

The materials required are: a wide mouthed bottle with bottom removed,

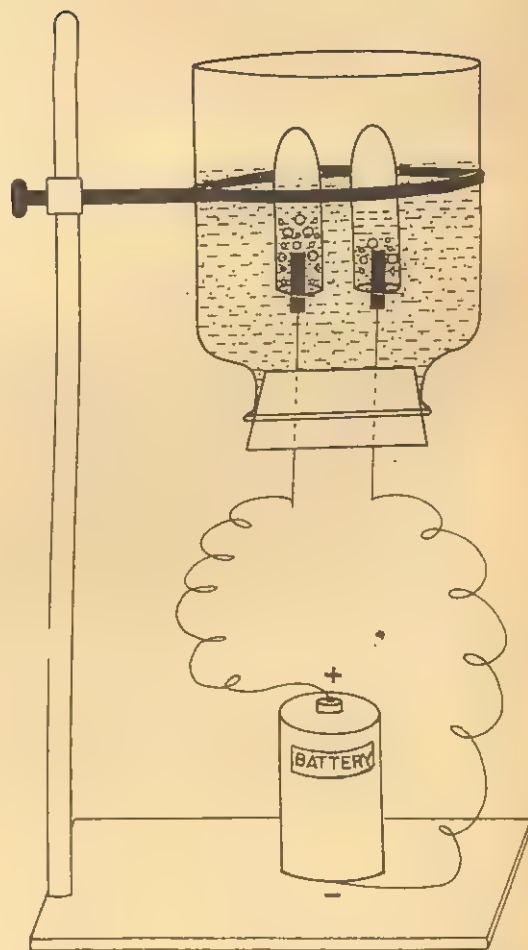


Fig. 11.1 Experiment set-up for the electrolysis of water

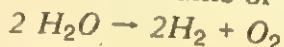
two stainless steel rods (or iron nails), cork with 2 holes in which the rods fit tightly, caustic soda, water, 2 copper wires joined with crocodile clips, source of 6 volts DC supply such as battery box or battery eliminator, stand with a ring.

**Procedure:** Set up the experiment as shown in Figure 11.1. Add water in the inverted bottle. Join the source of electricity and observe. You will find the bubbles of gas forming at both the stainless steel rods and rising to the surface. The release of the gases is very slow. About 2-3 pellets of sodium hydroxide are added to make water a better conductor. Bubbles will now form more rapidly at both the electrodes. Bubbles are of gas produced on passing electricity. In order to find the amount of the gases and to identify them, they should be collected. To collect gases disconnect the electric supply, fill two test tubes of same size completely with water, place the thumb on the mouth of one test tube, invert and place it in the bottle. Remove the thumb. The test tube remains completely filled with water. Place it over one rod. Repeat the same procedure and keep the second test tube over the other rod. Start the electricity supply now. Observe the gases filling in both test tubes. Are the volumes of gases in both the tubes same? One test tube seems to be collecting more gas than the other. After one of the test tubes is filled about half with gas, disconnect electricity. Measure the length of the gas column in each test tube. The ratio of the collected

gases seems to be 2:1. Continue the electric supply. When one test tube is filled with gas, remove and cork it. Test the gas by bringing a burning match stick near its mouth and open the cork. The gas burns with a popping sound and water is formed. This property is shown by hydrogen gas.

Let the other test tube be filled with gas. Remove it and introduce a glowing splinter into it. The splinter catches fire and burns brightly. Oxygen gas has similar properties.

This teacher demonstration shows that water is made up of two volumes of hydrogen and one volume of oxygen.



#### ANSWER THESE

1. What is electrolysis? What products do you obtain during the electrolysis of water and in what proportion?
2. Fill in the blanks:
  - (i) When a burning matchstick is brought near hydrogen gas, it \_\_\_\_\_.
  - (ii) When a balloon is filled with hydrogen gas and released, it goes up high towards the sky. This indicates that hydrogen is \_\_\_\_\_ than air.
  - (iii) If hydrogen gas is introduced to a fire, it will \_\_\_\_\_. If water is thrown on the fire, it will \_\_\_\_\_.

#### 11.2 Some Interesting Physical Properties of Water

You already know that water freezes into solid ice at  $0^\circ\text{C}$  and boils into steam

(gas) at  $100^{\circ}\text{C}$ . Freezing and boiling are physical changes. During these changes the molecules of water are not broken down or converted into something else.

An interesting physical property of water is its density. Usually, the density of a substance is higher in the solid state than in its liquid state. That is, the solid is heavier than the liquid. But with water it is just the *opposite*, as you will see in this activity.

### Activity 1

Take a little solid butter or candle wax in the middle of a large spoon and warm the spoon at the bottom. You can do this by using a lighted candle well below the spoon, or even by simply keeping the spoon in the sun, for a few minutes. Note that the melted liquid is at the top and the solid butter or wax remains at the bottom. It does not float at the top of the liquid.

Now take a glass of water and put a few pieces of ice in it. Watch now that the ice floats at the top. Push it down below the water level with your finger. It will come up again to float at the surface. Ice is lighter than water while solid butter is heavier than the melted liquid butter.

Solid water or ice is lighter than liquid water. It means that the density of ice is lower than that of water. The density of a substance is its mass divided by its volume. That is,  $\text{density} = \text{mass}/\text{volume}$ . It means that for the same mass (say 10 grams) of ice and of water, the volume of ice is more than that of

water. Therefore, water expands in volume when it is frozen to form ice! This is not so with ghee or coconut oil. They contract upon freezing.

Now imagine the severe winter in the Himalayas where the temperature can go down even below  $0^{\circ}\text{C}$ . The water that is in the municipal supply tubes and pipes will freeze at this temperature to ice. This freezing of water will cause an expansion in the volume. If the pipes and tubes are not strong, they can then crack, develop leaks or even burst!

The lower density of ice is inconvenient for some of our countrymen in winter. But it is this physical property of water that helps the fish in the Himalayan lakes. When the winter temperature is below  $0^{\circ}\text{C}$ , the water in the lake will start freezing to ice. The frozen ice will float at the top of the lake and cover it well. This ice will then act as a *coat* for the water below. It will not easily allow the cold outside to reach the water beneath. This is quite like our wearing sweaters in winter. The sweater prevents the outside cold from reaching our bodies. The *coat* action is another nice physical property of water. That is, water does not conduct heat very well. So, even if the temperature on the surface of the lake is  $0^{\circ}\text{C}$ , it is still above  $0^{\circ}\text{C}$  inside the lake since the ice coat insulates the water. The fish in the lake can swim and live, and not freeze to death.

Another physical property of water that is useful, is its heat capacity. You have learnt in Chapter 5 that the heat

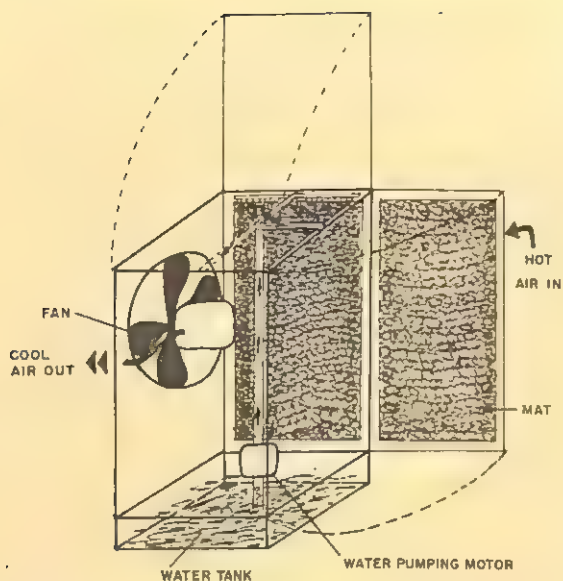


Fig. 11.2 A desert cooler

capacity of water is the highest among all liquids. This property of water is used to cool engines. Water is circulated around a car engine using the radiator pump. The engine is protected from getting too hot. Also, you might have seen hot water bags made of rubber. These are used in hospitals and homes to keep parts of the patient's body warmer. They are filled with hot water and they keep warm longer. If they are filled with any other liquid, they would cool down faster.

A nice use of this property of water is in room coolers or desert coolers. A picture of such a cooler is shown in Figure 11.2. Water is kept in a tray at the bottom. A pump circulates this water which drip on the mats kept at three sides, keeping them constantly wet. The fan takes the warm air from outside towards the room. The air enters

through the mats and evaporates the water. The evaporating water absorbs heat from the air and cools it. The cool air is then pushed into the room by the fan. We get cool air as a result.

Many of these properties of water are because its molecules attract each other. This leads to their trying to stick to one another. This attraction between water molecules is partly electrical in nature. We can see this electrical nature of water by the following activity. Water does not conduct electricity well, but an electric bulb can be fused if there is moisture on the wires. Water short-circuits electrical connections.

### Activity 2

Fix a burette on the stand with a clamp. Fill it with water and allow a thin stream or a jet of water to come out of it. Rub a plastic comb briskly in one direction repeatedly with a cloth. Bring the comb near the water stream. You will see the water stream bending towards the comb. The comb was charged by rubbing with the cloth. The water shows attraction towards the charged comb. This activity shows that water is attracted electrically. This is the basis of the intermolecular attraction of water.

The sticking together of water molecules is like children holding hands in circles. Various arrangements are possible; many using both hands to hold, some with one hand and some not holding at all. All holding hands is a highly ordered arrangement. But it is a

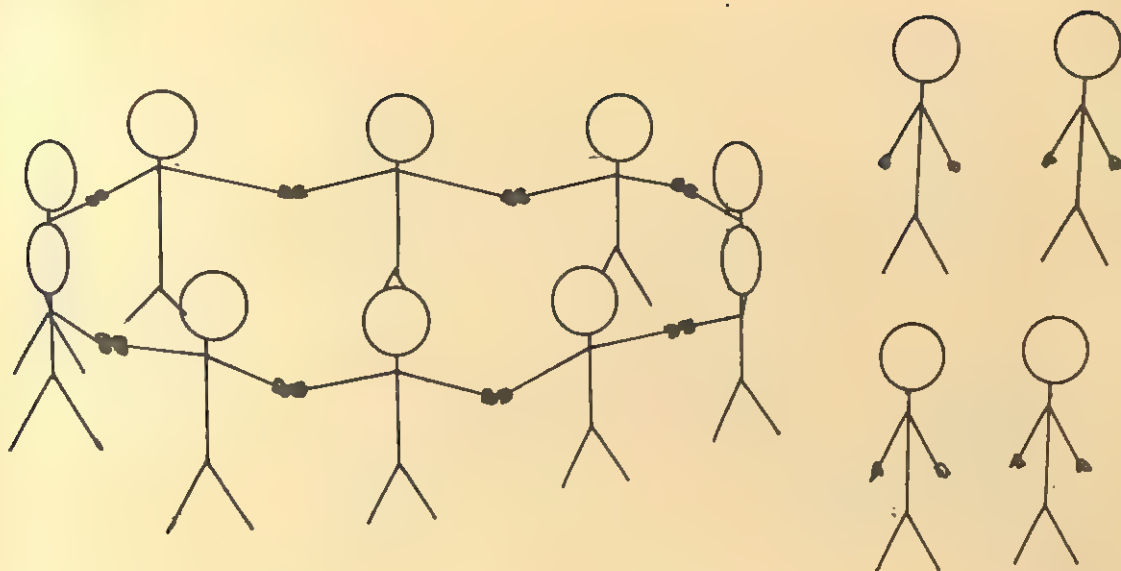


Fig. 11.3 The arrangement on the left is somewhat like the arrangement of water molecules and the arrangement on the right is similar to the free molecules of water.

loose arrangement. This is how ice will be. None holding hands and staying free is like steam. We show this in Figure 11.3. Very cool water at around  $4^{\circ}\text{C}$  is the most packed arrangement. Therefore, the density of water is highest at  $4^{\circ}\text{C}$ .

#### ANSWER THESE

1. What should be done in places like Leh, Ladakh, in winter to prevent the water pipes from bursting? Remember, whatever has to be done will cost money. Therefore, think of the cheapest and the best method.
2. How does a desert cooler work?

#### 11.3 Water Attacks Metals

Water reacts with some metals. Metals such as sodium, potassium and calcium

react vigorously with it at room temperature.

#### TEACHER DEMONSTRATION

##### *Reaction of Sodium with Water*

Fill a trough with water. Cut out with a knife a small piece of sodium of the size of a pea. Remove the oil on the sodium piece with a filter paper and drop it in water. The sodium reacts with water and darts around the surface. A flame is also seen near the surface.

Sodium metal reacts with water to form hydrogen gas and sodium hydroxide solution. Due to the heat evolved in this reaction the hydrogen catches fire and burns.



Magnesium metal is a little more

sluggish. It reacts with hot water and gives hydrogen and magnesium hydroxide solution.



Many other metals react with water to form oxides and hydroxides. Iron is one such metal which forms iron oxide. The oxide formed by iron is called *rust*. Iron rusts slowly in water. Iron is used in many buildings, factories, bridges, ships and vehicles. The slow rusting of the iron here causes great damage called *corrosion*. This leads to a weakening and collapse of the structure. Prevention of rusting of iron thus becomes very important and is usually done by coating the iron with other metals or paints.

#### ANSWER THESE

1. Fill in the blanks:

- (i) Water reacts with metals such as \_\_\_\_\_ and \_\_\_\_\_ at room temperature.
- (ii) Magnesium reacts with hot water to form \_\_\_\_\_ and \_\_\_\_\_.
- (iii) Water has the maximum density at \_\_\_\_\_ °C.
- (iv) When water at 4°C is cooled or heated, its volume \_\_\_\_\_.
- (v) Ice floats on water. This means that in ice, the molecules have \_\_\_\_\_ space between them.
- (vi) There is a \_\_\_\_\_ force between molecules of water.
- (vii) The car radiator cools the engine by circulating \_\_\_\_\_ around it.

2. When the Arctic sea freezes, why do the fish not die?

#### 11.4 Water Dissolves Many Substances

Water has capacity to dissolve many compounds. Rain water is pure water, but after falling on ground it comes into contact with several minerals there and dissolves some of them.

##### Activity 3

Collect a sample of water from any source. Filter it using a filter paper placed in a funnel into an evaporating dish. Place the evaporating dish on a tripod stand. Heat it with a lighted spirit lamp. When all the water has evaporated, observe the residue.

Water dissolves many substances. They may be solid, liquid or gas. Some substances dissolve in less and some in more amounts. The gases like oxygen and carbon dioxide are soluble in water. It is only through the dissolved oxygen in water that fish can survive. Fish have special organs called *gills*. The gills help fish in taking up the dissolved oxygen. Watch a fish in a tank, pond or in an aquarium. You will see the fish moving its gills all the time. It extracts the oxygen from the water and expels the water through the gills. This is how fish breathe. We, of course, take the oxygen in the air directly by breathing it into our lungs.

The following activity shows that water has dissolved gases in it.

#### Activity 4

Fill a boiling tube completely with water. Fit a rubber cork containing glass tubing to the boiling tube. Fill a trough with water. Invert the boiling tube and fit it to the clamp so that it is standing. The open end of the glass tube should dip in the water in the trough. Heat the boiling tube in the middle with a lighted spirit lamp. After some time you will find tiny gas bubbles forming in the test tube and collecting at the top. Stop heating when the water is about to boil.

This activity demonstrates that as the water is heated, it liberates some of the dissolved gases. This property is of some importance to life. Often during summer time, fish in shallow ponds die. The water in the pond becomes hot due to the summer heat. As a result, the amount of dissolved oxygen goes down and the fish die.

#### Activity 5

Take a beaker and fill it half with water. Add a small amount of sugar to the beaker and stir with a glass rod. Continue adding sugar until it no more dissolves. The solution in which no further sugar dissolves is called a *saturated solution*. Place the beaker on a tripod stand and heat it for 5 to 10 minutes. Add more sugar and try to dissolve it by vigorous stirring. You will notice that more sugar is needed to make the solution saturated at this temperature. If you heat the solution more, you will see even more sugar dissolving.

In many places, rain water passing through layers of soil and rocks dissolves considerable amount of salts. The water tastes salty. This water is called *saline water* (saline means salty). Salinity of water is caused by salts dissolved in water. In Gujarat and Rajasthan, water salinity is a serious problem.

#### WHAT MAKES SEA WATER SO SALINE?

Rivers bring water containing dissolved salts and minerals into the sea. The sea water is continuously evaporated by the sun. This evaporated water collects as clouds and falls as rain. The rain falling on land dissolves more salts and minerals there and brings it to the sea through rivers. Thus, the sea continues to get salts and minerals. This continuous process makes the sea water high in salinity. One litre of sea water has about 35 grams of salt. The water that we drink daily has no more than 1-2 grams of salt per litre.

Sea water is not suitable for drinking, that is, not *potable*. Drinking of sea water may induce vomiting. Many plants cannot tolerate salt water.

#### Activity 6

Take 2 pots with similar seedlings. Water one pot with saline water and the other with tap water or well water daily and observe the plants. Which plant starts wilting and which is healthy?

This activity shows that saline water is not suitable for agriculture. Saline water is not suitable for industries either.

It causes metals to rust and corrodes them.

In places where only saline water is available, pure water is obtained from it. One method of doing so is called *distillation*. The distilled water so obtained is not *potable*, or good for drinking, because it will dissolve vital chemicals from our bodies. It is thus mixed with some salty water and used for drinking. Drinking water containing acceptable amounts of dissolved salts is also obtained by other methods.

You have already learned in Class VI about hard and soft water. When a small amount of soap is added to soft water and it is shaken, a frothy lather is seen. But soap does not lather well with hard water. The hardness of water is due to the presence of calcium and magnesium salts in water. These salts chemically react with soap and form insoluble substances. Therefore, enough soap is not available to form lather. Thus hard water makes washing clothes with soap more difficult. Hence the name hard water.

Like saline water, hard water is also not suitable for industries. Continuous usage of hard water deposits a layer of salt in the pipelines carrying hard water. This salt deposit is not soluble in water and thus chokes the pipelines. Also, when hard water is used in boilers that generate steam, it leaves a coat of salt in the sides of the boiler. This coating, called scales in the boiler, makes the heating inefficient and can even crack

and burst the boiler. These salts or salt deposits thus formed are removed by acid treatment. When washed with dilute hydrochloric acid (HCl) or nitric acid (HNO<sub>3</sub>) solution, the scales and the salt deposits dissolve, releasing CO<sub>2</sub> gas. The boiler is now descaled and safer to use, after the acid is washed off. In some industries hard water is softened by passing through special materials called *ion exchange resins*. These resins exchange the calcium (Ca) and magnesium (Mg) in the hard water for sodium (Na) or potassium (K). Hard water can also be purified by distillation just as saline water. Large scale production of distilled water in this manner is carried out in Arab countries where fresh water is scarce.

#### ANSWER THESE

1. How will you show that water contains dissolved gases?
2. How does rain water become saline?
3. How is common salt produced in India?
4. What makes water hard?

#### 11.5 The Presence of Unwanted Material Makes Water Polluted

Water is the most important chemical required by all living beings. Yet, in many areas of the world, there is acute shortage of potable water. Many regions in our country suffer from an acute drought every year. India is surrounded

by seas and oceans. But it still is like the lines of the poet *Coleridge*. On a voyage on the seas, when the sailors suffered a lot because of thirst though they saw outside the ship nothing but water — water, water everywhere, not a drop to drink!—how can one drink that saline sea water?

Inland water is often polluted by several chemical substances and tiny living organisms. It is called polluted when it is unfit for drinking or bathing. Polluted water is also harmful to plants and animals.

Let us discuss the *major causes of pollution of water*.

In many areas people defecate in open fields. The rain washes away human excreta and animal dung into the nearby water sources. The dung contains several harmful micro-organisms that can cause diseases such as diarrhoea, dysentery and jaundice. Worms also enter into our bodies as tiny eggs and grow there. Tape worms, hook worms, and round worms are some of the examples. In many places, human excreta is dumped into the nearby rivers. This can cause diseases to the whole population, that are called *epidemics*. Sometimes gutter water gets mixed with the drinking water that is carried in municipal pipes due to faulty water and drainage systems. This happens when pipes leak and the polluted water causes diarrhoea or jaundice.

In order to prevent pollution, human and animal excreta should be prevented

from mixing in water sources. This can be achieved by building pit latrines and treating the sewage properly before putting it in rivers. Dead bodies of humans and animals should also not be thrown into rivers.

The excreta and other garbage can be treated in a biogas plant. Recall our discussion of the biogas plant in the last chapter. Figure 11.4 shows such a plant.

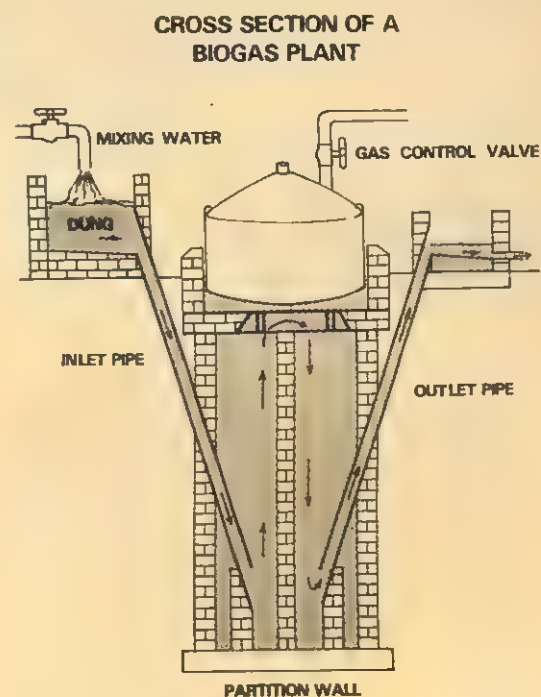


Fig. 11.4 (a) A bio-gas plant

In this plant, micro-organisms are used to decompose the excreta and produce biogas which is a good fuel. The remaining slurry is harmless and is used as a good manure in the fields. See how



Fig. 11.4 (b) *A plant in operation in a village*

useful the biogas plant is. It is now becoming more and more popular.

Chemical factories often produce many toxic chemicals as wastages. In most of the industries these are not properly treated before throwing them out. This industrial waste is discharged into rivers. The river water thus becomes poisonous for the fish and the river plants. A flowing river can purify a certain amount of its water by natural processes. And many industrial waste products cannot be cleaned easily by natural processes. The water stays polluted and causes several diseases to the people who use it.

What are some of these chemicals that pollute the water? Where do they come from? And how can we remove them and make water safe for use? Compounds of several metals such as Lead (Pb), Mercury (Hg), Cadmium (Cd), Chromium (Cr) and Arsenic (As) are highly toxic. These are used in the chemical, textile and leather industries. Dye-stuff and paint factories use and throw out as waste material many organic compounds that are harmful for health. Agriculture uses fertilizers and pesticides. Many of these chemicals get washed off by rain water into ponds, rivers and seas. Now, these chemicals do

not get decomposed by natural methods or by microbes. Hence, these chemicals get accumulated and pollute the water.

Control and removal of polluting substances need to be done. The source or the factory level is one, where these toxic chemicals must be treated chemically and converted into harmless compounds. This is to be done by the factories and the industries themselves before they release the chemicals to the environment. The second level is the purification of the rivers and streams, ponds and lakes. This is done both by the industries and the government. One such example is The Ganga Purification Project. The Indian Government has taken up the task of purifying the river Ganges. This is being done by treating the sewage in all towns and cities on the banks of the river. This treatment makes the sewage water harmless before it is released into the Ganges. The industrial wastes will be initially treated at the factories. The treated water is then let out into the river. Along the banks of the river will be planted many trees and shrubs. These not only add beauty to the scenery but also help in cleaning up the environment.

#### ANSWER THESE

1. How does water get polluted in a well?
2. Name 4 metals whose compounds are poisonous.
3. How can the pollution of river water

be controlled?

#### YOU NOW KNOW

- Liquid water is heavier than solid ice.
- The lower density of ice helps in letting fish survive.
- The heat capacity of water is high and its heat conductivity poor.
- Water dissolves many substances.
- Sea water is highly saline. Each litre of this contains about 35 grams of dissolved salt.
- High salinity in water is harmful for agriculture, to animals and for human use.
- Hard water can be treated and softened.
- Water gets easily polluted.
- Water pollution is caused by industries and by improper health practices.

#### NOW ANSWER THESE

1. Describe two uses of water as a carrier of heat.
2. How healthy a pond is, depends on the amount of oxygen dissolved in it. What happens when there are too many fish in the same little pond? Will the fish have enough oxygen for them to survive? What would be the effect if too many chemicals are dumped into the lake?
3. What are some of the industries that pollute water?
4. Identify the sources of water pollution in your neighbourhood.

## CHAPTER TWELVE

# Air

AIR IS EVERYWHERE on the earth. We are all living under an ocean of air. All living things need air. In this chapter you will learn about the various components of air. Human activities introduce several harmful substances in air. Such activities pollute the air. Air pollution must be controlled.

### 12.1 Air is a Mixture

For a long time air was considered to be an element. Oxygen was identified as one of the constituents of air by Priestley in 1774. We discussed this point in Chapter 2. It combines with metals as well as non-metals to form oxides. The amount of oxygen in dry air is about 21% by volume.

Nitrogen is the major constituent of air. It is not a reactive element like oxygen. Nitrogen forms 78% of the volume of dry air.

Another important component of air is carbon dioxide. The carbon dioxide gas is given out by animals during respiration. Plants use carbon dioxide to prepare carbohydrates. Carbon dioxide  $\text{CO}_2$  makes up about 0.03% of the composition of air.

Later on it was found that air contains very small amounts of the inert elements—helium, neon, argon, krypton, xenon and radon. These are the inactive components of air. All together, these constitute less than 0.9% of air.

Air always contains water vapour. It is present in air as a result of the evaporation of water from oceans, rivers, lakes and streams. Water vapour is also given out by plants and animals. The land on warming by sun also gives out water vapour. The amount of water vapour in air varies from place to place. It also varies at one place during day and night and from day to day. At any temperature, air can hold a certain maximum amount of water vapour. What happens when this capacity of air to hold water vapour is exceeded? It then condenses into water droplets and forms dew or rain. If the temperature in the area is very low, the water droplets freeze and fall as mist or hail or snow. The content of the water vapour in air is called the *humidity*.

In the later part of summer, the humidity of the air increases. People sweat a lot in such weather. And the

sweat does not readily evaporate because of the humidity in the air. Such weather then becomes muggy and uncomfortable. This type of weather is experienced in areas close to the sea and during cloudy days. On the other hand, during winter the higher humidity of air makes it feel more chilly.

When wet clothes are dried in air containing small amounts of water vapour, they dry quickly. Wet clothes take much longer to dry when the humidity is high. At low humidity, water evaporates more readily. Water evaporates very slowly if the atmosphere has high humidity.

Air also contains tiny solid particles. These particles can easily be seen in the beam of sunlight in a room. The solid particles of sand and soil are carried into air by strong winds. They remain suspended in air for some time. Solids such as pollen from flowers and light seeds are also introduced into air by plants. Fuels are burned in homes, factories, power stations and various types of vehicles. Burning of fuel gives rise to smoke. The smoke introduces various types of solid particles in air. The amount of solid particles in air is different at different places.

The amount of water vapour and solid particles in air varies from place to place. The other constituents of air remain nearly the same.

#### ANSWER THESE

1. Name five components of air.

What are winds? During the day the sun warms the earth. The land at different places is heated to different temperatures. Rocks, sand and dry soil get heated up very readily while fields, forests and woodland get heated very slowly. The land passes off the heat to the air. The heated air, being lighter, tends to move upwards. Cooler air from the surrounding area moves in and takes its place. This movement of the air is known as *wind*. Wind is thus caused by differences in the temperature and the pressure of air. In areas close to large water bodies such as the sea, rivers or lakes, the water temperature rises very slowly due to absorption of energy of sun. The land gets heated readily to higher temperatures. This is because the heat capacity of water is 1, while that of air is about 0.45. The cooler air moves from water bodies towards land in day time. At night the land cools much faster than the water. Usually after midnight, air from over the land is cooler and hence moves towards the water. The larger the pressure differences, the stronger will be the winds.

2. How will you demonstrate that water vapour is present in air?

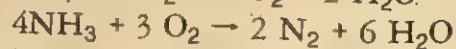
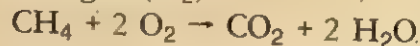
3. How do you know that solid particles are floating in air?
4. Fill in the blanks:
  - (i) The gas present in the largest amount in air is \_\_\_\_\_.
  - (ii) During photosynthesis \_\_\_\_\_ gas is used up and \_\_\_\_\_ gas is formed.
  - (iii) During respiration \_\_\_\_\_ gas is taken in and \_\_\_\_\_ gas is given out.
  - (iv) For supporting burning \_\_\_\_\_ gas is essential.
  - (v) Smoke is formed when \_\_\_\_\_ is burned.
  - (vi) The percentage of \_\_\_\_\_ in air varies from place to place.

### 12.2 Constituents of Air and Their Uses

The major constituents of dry air are nitrogen (78%), oxygen (21%), noble gases (0.9%) and carbon dioxide (0.03%). All these have very low solubility in water. Rain dissolves these gases only to a very small extent. Thus, the composition of air is not affected by rain.

Has the composition of air always been the same? Not so. In fact, it has changed remarkably during the history of life on the earth. Earth was formed about 4.5 billion years ago (a billion is one thousand million). At that time, the temperature of the earth was very high. With passage of time, the earth cooled and molecules began to form. Gases also began conden-

sing into liquids and solids. The earth began attaining a structure: Heavy metals formed the central portion or the core of the earth, while compounds of iron, aluminium and the non-metals formed the outer parts and the crust of the earth. The atmosphere of the primitive earth was made of methane ( $\text{CH}_4$ ), ammonia ( $\text{NH}_3$ ) and water vapour. There was no oxygen gas at all in the atmosphere. All the  $\text{O}_2$  was "fixed" as the oxides on the crust. With further cooling, large water bodies called the oceans were formed. Life on earth originated around 3.5 billion years ago. All these life forms were *anaerobic*, that is they did not use the air or oxygen. We still have many of those ancient life forms such as bacteria on earth today! Soon, thereafter, plants were formed. And with the photosynthesis that plants do, oxygen was introduced into the atmosphere. This oxygen reacted with the methane and ammonia in the air to give carbon dioxide ( $\text{CO}_2$ ) and nitrogen ( $\text{N}_2$ ).



The  $\text{CO}_2$  is used by plants while the  $\text{O}_2$  is used by animals. And while plants use  $\text{CO}_2$  and release  $\text{O}_2$ , animals do the opposite.

Thus, the atmospheric composition

has gone through a remarkable change over the years. Since the last 2 billion years, the composition has stayed nearly constant after plants and animals stabilized the atmosphere.

### NITROGEN

Nitrogen is the major component of air. About 78% of air by volume is nitrogen. Nitrogen is quite unreactive normally. Under the high energy conditions of a lightning in the cloudy sky, nitrogen reacts with atmospheric oxygen to give various oxides of nitrogen. These oxides dissolve in water and come down to the soil as *nitrates*.

Atmospheric nitrogen is used by some living organisms to make compounds of nitrogen for biological use. Other organisms in the soil use the nitrates in the soil for their growth. Some of these organisms are bacteria and plants and other animals. Animals do not directly use  $N_2$  or the nitrates, but get their nitrogen supply only from plants and other animals. The waste products of animals contain nitrogen compounds. When these are used as manure, plants grow well.

### OXYGEN

#### TEACHER DEMONSTRATION

*The Percentage of Oxygen in Air*

**Materials:** A wide mouthed bottle with bottom removed, a rubber cork having a

deflagrating spoon, yellow phosphorus, trough, water, ruler, glass marking pencil.

Fill the trough about two-thirds with water. Place the special wide mouthed bottle in it. Mark the water level in the bottle with a glass marking pencil. See Figure 12.1 for the set up. Take a small amount of yellow phosphorus in the deflagrating spoon. Insert it in the bottle and cork the bottle tightly. Wait for some time. The yellow phosphorus will

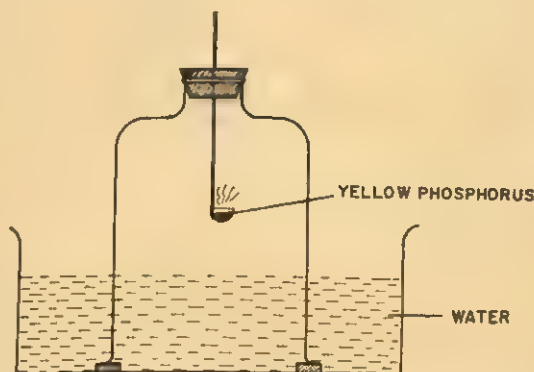


Fig. 12.1 Experimental set-up for measuring the percentage of oxygen in air

slowly react with oxygen in the air and catch fire. The water level will rise in the bottle due to the loss of oxygen. Mark the maximum water level with the pencil. Remove the bottle. Invert the bottle and find out the volume of water required to fill it upto to the first and the second mark. The difference between the volumes is the amount of oxygen present in air. The volume of water upto the first mark gives the volume of the air in the bottle.

This experiment shows the percentage of oxygen in air is *about 21% by volume*.

The plants and animals living in water use the carbon dioxide and the oxygen which are dissolved in water for their needs. The oxygen in the water comes from the photosynthesis of the water plants. This can be seen in the following activity.

### Activity 1

Fill a jar or beaker to about three-fourths with pond water. Put a small water plant in it. Cover it with a funnel. Fill a test tube with water. Put your thumb on the mouth of the test tube. Invert the tube and introduce it in the jar. Release the

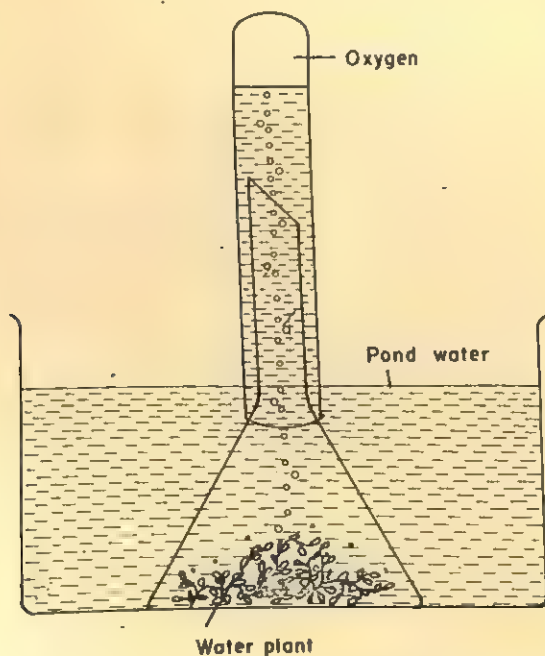


Fig. 12.2 Collection of oxygen released by photosynthesis by a water plant

thumb and place the test tube over the stem of the funnel, as shown in Figure 12.2. Put the jar in the sunlight. In a short while you will find bubbles of gas escaping from the leaves and collecting in the test tube. Allow the gas to fill up the test tube. The gas can be tested with a glowing splinter. The splinter burns brightly in the gas, showing that it is oxygen.

### SEPARATION OF THE VARIOUS CONSTITUENTS OF AIR

Many industries need pure oxygen and pure nitrogen. They obtain these gases from air. Air is compressed to a high pressure and cooled. When this is repeated several times, the air turns into a liquid! This is quite similar to condensing steam into liquid water. Liquid air is a mixture of liquid  $O_2$  and liquid  $N_2$  and has a low boiling point about 200 degrees below zero, that is,  $-200^\circ C$ . When it is warmed to  $-196^\circ C$ , nitrogen in it becomes a gas and is separated while at  $-183^\circ C$ , oxygen boils off and is separated.

### USE OF THE VARIOUS CONSTITUENTS OF AIR

Oxygen is essential for life. Pure oxygen is directly given to patients suffering from breathing difficulties. Oxygen cylinders are also carried by mountain climbers, sea divers and astronauts. Mixtures of oxygen with other gases like hydrogen or acetylene are used for welding metals. In modern steel plants

oxygen is passed through molten iron to burn out carbon and make steel. Liquid oxygen is used in rockets to burn the fuels.

Nitrogen compounds are essential for the growth of plants. Earlier, only animal dung was used as manure for plants. But these days, various nitrogen compounds such as ammonia, ammonium nitrate, ammonium sulphate, potassium nitrate and urea are used as fertilizers in order to increase crop yields. Several nitro compounds are used as explosives, such as trinitrotoluene (TNT), nitroglycerine and nitrocellulose. Many nitrogen containing compounds are also used as dyes and drugs.

Carbon dioxide is used in aerated drinks such as soda water, lemon, orange or cola. This gas is dissolved in such drinks under pressure. That is why when you open a bottle of soda water, you can hear the pop sound and see bubbles of  $\text{CO}_2$  escaping. These drinks are mildly acidic and give a tangy taste to the tongue. Alcoholic beverages such as beer also contain carbon dioxide. Carbon dioxide is used in fighting fires. It is heavier than air and cannot burn. We saw in Chapter 3 how a fire extinguisher works.

Gaseous  $\text{CO}_2$ , upon cooling to  $-57^\circ\text{C}$ , directly becomes a solid. The solid form of carbon dioxide is known as *dry ice*. It looks like ice but does not wet. Hence the name. It is used to keep ice cream and other items frozen.

Argon is used for filling electric

bulbs. The filament of an electric bulb is heated by passing electric current and the hot filament emits light. If air is present in the bulb, the hot filament will react with oxygen and get worn out in a short time. As a protection for the filament, the bulb is filled with the inert gas argon.

Neon and helium gases are present in air in very small amounts. Helium is used to obtain very low temperatures. Neon is used in special electric tubes called neon sign tubes.

#### ANSWER THESE

1. Describe the process by which oxygen is naturally produced.
2. How is pure oxygen made on a large scale.
3. Give three uses of carbon dioxide.
4. Give two uses of nitrogen.
5. Describe an activity which shows that oxygen is produced by plants.
6. Why is nitrogen important for living organisms?

#### 12.3 Air Pollution

Pollutants are harmful or undesirable substances. These pollutants may be harmful to plants or animals or both! When such pollutants are present in air it is said to be polluted. Air pollution is largely due to human activity.

The wind carries soil, dust, pollen and other particles. Such particles in the air often cause allergy, sneezing and health problems. Factories and power houses produce large quantities of

smoke. This smoke contains particles of coal, ashes and some toxic compounds. Similarly cement, steel plants and chemical factories produce large amounts of particles that pollute the air. Or, think of what a smoker does. Cigarette smoking introduces smoke into a room. This smoke goes also into the lungs of non-smokers and affects their health. Burning of fire-wood and cow-dung cakes at home produces smoke which is bothersome and even harmful. By adding a chimney to the stove (*chulha*) the smoke can be removed from the house. Vehicles such as scooters, cars, buses, and trucks also produce smoke by burning petrol or diesel. Such auto exhaust is a major cause of air pollution.

Other products of burning may also cause pollution. All fuels contain carbon. When such a fuel is completely burnt, carbon dioxide is formed. Most of the time the fuels do not burn completely. In that case both carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>) are formed. Carbon monoxide is a poisonous gas. It combines with blood and many proteins of the body and prevents them from doing their activities. In winter, some homes are heated with coal fire. You can imagine what can happen in a house where all the windows and doors are closed and a coal fire is burning. Carbon monoxide CO gas can accumulate and become very dangerous or even fatal. Proper ventilation of houses and bedrooms, even in winter, is thus essential.

Oxides of sulphur and nitrogen are

also harmful to health. Coal and petrol contain small amounts of sulphur, which on burning gives *sulphure dioxide* SO<sub>2</sub>, an acidic oxide that affects skin, lungs and other tissues. Similarly, the oxides of nitrogen, formed at the high temperatures that some engines reach, are also poisonous.

In refineries and power plants, it is thus important to remove the oxides of sulphur and nitrogen before the gases are let out. Otherwise, these will be carried in the wind and rain and will produce what is called *acid rain*. Acid rain will damage cement, steel, marble, bricks and, of course, living organisms.

A few years ago, there was a fear that the Taj Mahal in Agra could be damaged by acid rain. In Mathura, north of Agra, a petroleum refinery was being set up, and there was the danger that the refinery could produce and let out sulphur dioxide SO<sub>2</sub>,\* nitrogen dioxide NO<sub>2</sub> and other oxides. If these were carried by the wind towards Agra, the Taj Mahal could be easily damaged. Hence special precautions have been taken in the Mathura refinery. One way is to scrub down the exhaust gas with water before it leaves the chimney. This scrubbing dissolves all the toxic gases and prevents their escape into the atmosphere.

With more industry and progress, the pollution of the air would become a problem. Wisdom lies in anticipating these problems and solving them before they cause damage. The Mathura refinery is such an example. Here the

problem was anticipated and solved so that the marble marvel at Agra is not damaged by acid rain.

#### ANSWER THESE

1. Would you call smoking a cigarette as polluting the air? Why?
2. What is acid rain?
3. How do vehicles cause pollution?

#### YOU NOW KNOW

- Air is a mixture of gases.
- The concentrations of water and of particles in air vary from place to place and from time to time.
- 78% by volume of air is nitrogen  $N_2$ , 21% is oxygen  $O_2$  and the rest are inert gases, carbon dioxide  $CO_2$  and water.
- Air gets polluted with pollutants.
- Acid rain is formed by the reaction of the sulphur oxides and nitrogen

oxides with rain water.

- Industrial progress leads to pollution. But with advance knowledge and planning, pollution can be controlled and avoided.

#### NOW ANSWER THESE

1. How are winds caused?
2. How did oxygen  $O_2$  originate in our atmosphere?
3. What is liquid air? How can it be made?
4. Fill in the blanks:
  - (i) Oxygen is prepared in the laboratory by heating \_\_\_\_\_
  - (ii) For welding metals, the gases used are \_\_\_\_\_ and \_\_\_\_\_ or \_\_\_\_\_ and \_\_\_\_\_
  - (iii) Solid carbon dioxide is called \_\_\_\_\_.
  - (iv) Electric light bulbs are filled with \_\_\_\_\_, in order to protect the \_\_\_\_\_ from chemical reaction.



## CHAPTER THIRTEEN

### Organisation of the Living Body

THE LIVING WORLD has organisms which differ widely in their external appearances. There are very small organisms like bacteria which cannot be seen by the eye easily. And there are very big trees such as the banyan tree and very large animals like the elephant. Some have bright colours and some have a pleasant smell. Some stay in water and some on ground. They all look different. But all of them do some common and basic activities in order to keep alive. For example, they all seek food. They convert this food in a form which they can store and use as energy. They expel the waste products of this conversion. They respond to external stimuli. Most importantly, they grow and produce more members of their species. All organisms convert the chemical energy stored in food to perform all these functions. Different organisms do these in different ways. The ways they do, depend on their structures.

A handcart, a bicycle and an aeroplane, all can take load from one place to other. Each of them looks so different from the others but they all do the same job. What is common among

them? Each of them needs energy to push or pull the load. We supply our body energy for the handcart and the bicycle. Aeroplanes use a special form of kerosene for their energy. They move fast and can travel long distances in air. Though all of them use energy to move load, each of them does so in a different manner. Their structures are different which suit their method of doing the task.

A single cell organism eats, digests, throws away the waste products, grows, moves and reproduces. Organisms that are made of many cells, that is *multicellular* organisms, do all these and sometimes many other jobs. Here the tasks are divided among groups of cells. The animal called hydra that lives in water is made up of many cells. The cells are arranged in such a way in the animal that some cells help in moving, some in catching food from the water and putting the food inside its stomach (gastric cavity). Inside the cavity, some cells digest the food and then the waste is thrown out. On eating the animal grows and makes more of its own kind. In this organism, all the cells do not do all the

jobs. Each type of cells performs one kind of task and does it in such a way that the whole organism continues living. How does a multicellular organism perform various tasks at the same time? How is its body made? And how does the structure of the body help in its performance? These are some questions we will attempt to answer in this chapter.

### 13.1 Organisation in Multicellular Organisms

Take the case of a bicycle. The rider pushes the pedals. This moves the chain system which then rolls the wheels. All these different parts of the bicycle are connected to each other in a systematic way so that movement is possible. We can say that the bicycle is an *organised structure* and has parts like chain (to rotate the wheels), wheels (to get going with the rider), handle bar (to change the direction), and so on. We can talk about the parts of the chain system or only wheels and how they do their jobs. We thus have various *levels of organisation*.

#### ORGANS AND ORGAN SYSTEMS

Complex multicellular organisms are made of different parts which do different jobs. We know that in a tree the leaves make food, the roots absorb water and salts from the soil and the stem carries them to the leaves and also holds the branches and leaves. We also know that we eat food using our mouth and then digest it using our stomach, intestines and so on. These structural

parts which perform a definite function of the body are called *organs*. Leaf is an organ and the stomach is also an organ. For a complicated process many organs are used. For digesting food you need the mouth, the stomach and the intestines. This kind of collection of organs which do a big job are called *organ systems*. Remember the bicycle and its organisation. Similarly all the *organs* and *organ systems* in an *organism* act in an ordered way to keep it alive.

#### TISSUES

Look at the picture of a leaf in Figure 13.1.

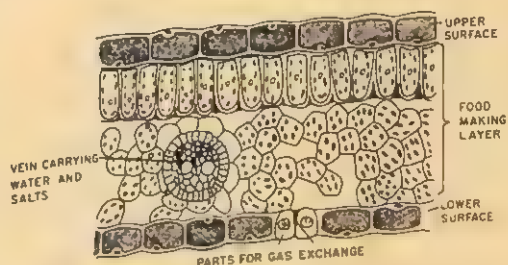


Fig. 13.1 Details of a leaf showing the various parts that do different tasks

You will see that it is made of many smaller parts. Each part does some specific job. For example, the upper and lower layers protect the inner parts and also regulate the water content and the exchange of gases ( $\text{CO}_2$  and  $\text{O}_2$ ). The veins carry water and salts and the food-making layer makes food. Your stomach also does the job of digestion with the help of its parts. One part helps in contracting and expanding for the food to mix properly. Another part sends

messages to the brain telling that you are hungry or have pain. It also has a part that absorbs the digested food. These smaller parts of organs are called *tissues*. Think of the wheel of a bicycle. You notice that the rim is round and the spokes are radially connected. The tyre is made of soft material. All these are organised in a specific way to help the wheel to roll. Similarly, the tissues in an organ have a particular arrangement. This arrangement of tissues helps the organ to perform its function. Tissues in turn are made up of *cells*.

## CELLS

Generally a *tissue* is a collection of similar *cells* performing a small set of functions. Just like the arrangement of tissues in the organs, the cells in the tissues also have specific arrangements. Sometimes they are bound by cementing material for forming the tissue structure. When the function of the tissue is to protect, the cells in it are packed side by side like a mat. When the function is to send water and salts to the leaves from the root, the cells are tubular and form bundles as pipes. We know that the cell is the smallest structural and functional unit of life. In multicellular organisms the organisation of the cells into different structures is the most important feature.

In the living world the cells are organised into tissues; tissues into organs, organs into organ-systems. Finally the proper organisation of

organs and organ systems makes the individual. In each of these levels the structure of the parts and their mutual arrangement helps them to do their work.

## Activity 1

Note down the parts of a bicycle and write their functions. For example, you can write as follows.

*Pedal*: for applying force with both feet. Then note down the connections between these parts, such as, "pedals connect to the chain system". There may be cases where one part is connected to more than one part. Can you compare these parts with any structure in your body?

We do many other activities than what a bicycle does. So the organisation of our body is more complex. You will see later that there are just a few major types of tissues which make our body.

## ANSWER THESE

1. Fill in the blanks:

- (i) All living organisms use \_\_\_\_\_ to carry on their basic activities.
- (ii) Multicellular organisms have different \_\_\_\_\_ to do different \_\_\_\_\_.
- (iii) The levels of organisation in multicellular organisms are \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_.
- (iv) The \_\_\_\_\_ are arranged in a specific order to make a tissue.

2. Why is a leaf called an organ?

3. How does the stomach perform various functions? Give one example.

### 13.2 Cells

A bacterium, a banana and a baby are different from each other. Yet, they are all made up of cells. Cell is the smallest unit of life which has a definite structure and performs a function.

There are many different kinds of cells. Cells from different parts of the leaf look very different. A cell from the brain looks very different from a cell from the skin. You have seen water-melon cells and human cheek cells earlier (Class VI). They looked very different. But if you look carefully inside the cells you will find some similarities in all of them. Figure 13.2 shows a general picture of a cell and some other cells in living organisms.

All the cells are enclosed in bags of different shapes. The borders of the cell hold a jelly-like material with many bodies of different shapes and sizes inside. The border is called the *membrane* of the cell and the jelly-like material is called the *cytoplasm*. One of the largest floating bodies, generally in the centre of the cell is called the *nucleus*. There are other bodies which are not easy to see even under the ordinary microscope. Each of them does some specific task. The *mitochondria* carry out respiration, and the *chloroplasts* make food in green plants. Some of the cells, especially plant cells and bacteria, have an outer *wall* surrounding the membrane to give them a rigid shape.

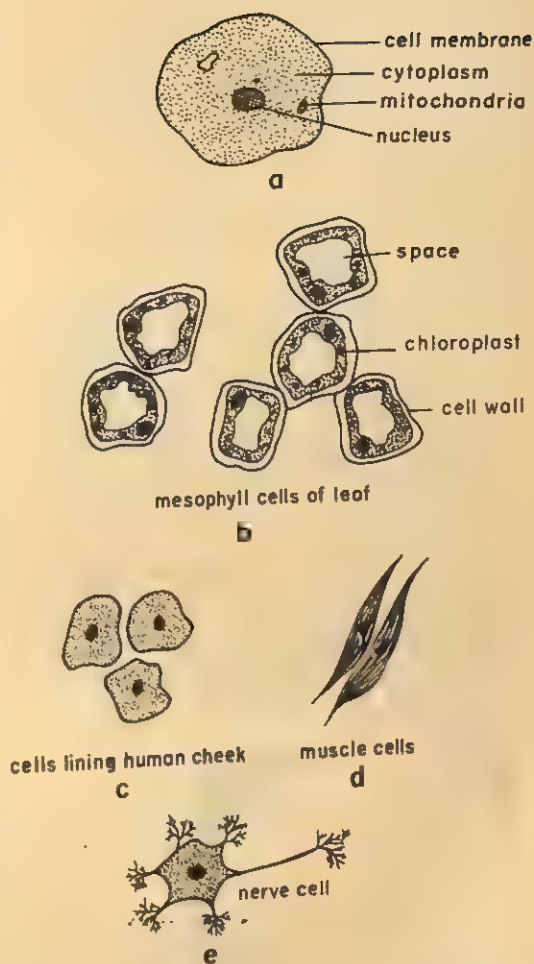


Fig. 13.2 Different Types of Cells: (a) the General Diagram of a Cell; (b) the Mesophyll Cells of a Leaf; (c) Human Cheek Cells; (d) Muscle Cells and (e) Nerve Cells or Neurons. See how differently shaped cells can be.

#### SHAPES AND SIZES OF DIFFERENT CELLS

Figure 13.2 (b, c, d & e) shows that cells can have very different shapes. The shape of a cell helps in its function. A

nerve cell (Fig. 13.2 e) is long and has net-like projections. This helps it to make many contacts with other nerve cells and send messages to the brain or other places in the body. Amoeba does not have any particular shape. It can move easily by extending portions of its body on any side.

Cell sizes can also vary a lot. The bacteria are generally less than 10 micrometres (1 micrometre = 0.001 mm) long and about 1 cubic micrometre in volume. A typical animal cell is about 1000-2000 cubic micrometre in size. There are larger cells also. In our body some blood cells are the smallest and the nerve cells are the largest. Figure 13.3 would give you an idea of how large the variation is in the sizes of cells.

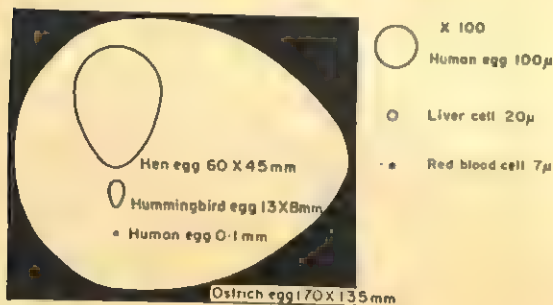


Fig. 13.3 The sizes of cells vary a lot. A single red blood cell is 7 micrometres in size while a single egg cell of the ostrich is about 25,000 times bigger.

### CELLS GROW AND DIVIDE

Many cells grow in size after digesting food. After reaching a critical size, a cell then splits into two similar cells. These are called the daughter cells and they are

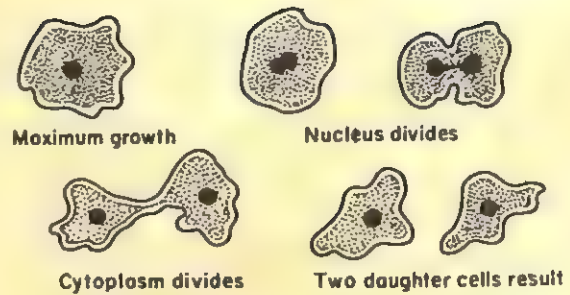


Fig. 13.4 Scheme showing how an amoeba divides

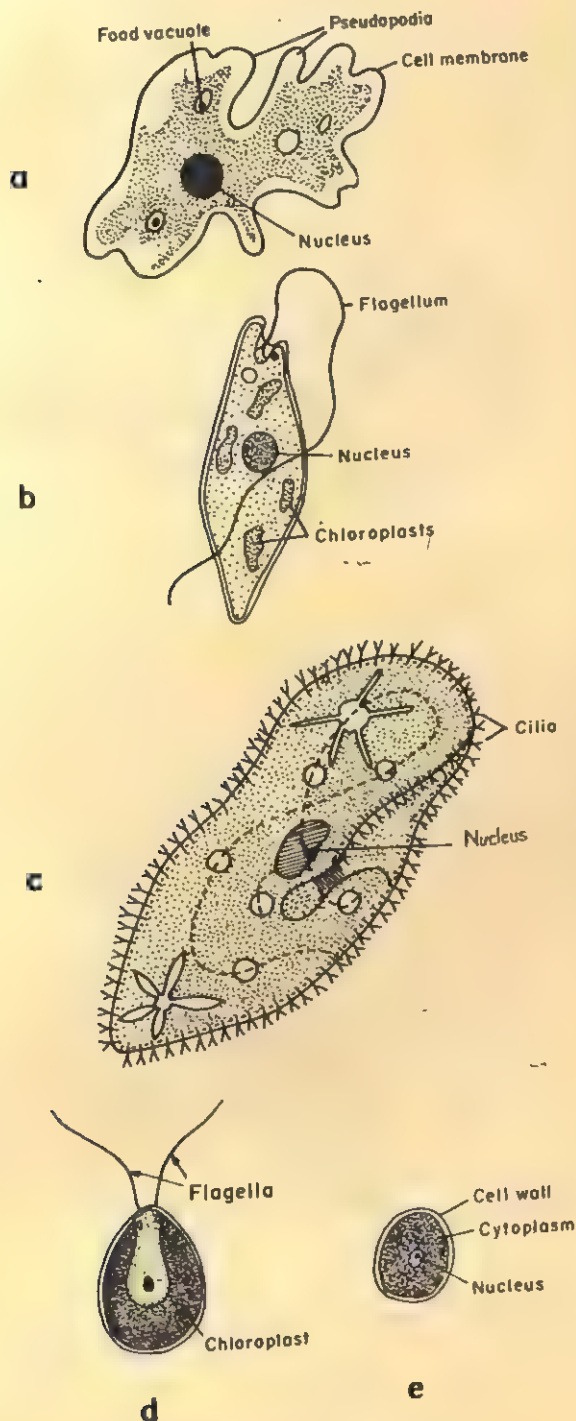
identical to the mother cells. Figure 13.4 shows the division of an amoeba.

How does a small plant grow into a big tree or a kitten to a cat? The main factor is increase in the number of cells. In young animals and plants cells grow and divide rapidly. Some cells in our body grow and divide all through the life. The cells in the skin are such. But the brain cells (nerve cells) do not grow in number after a certain age.

### CELLS AS ORGANISMS

Some cells can do all the basic activities of life and live independently. These are called *single-celled* organisms. *Amoeba*, *Paramecium*, *Chlamydomonas*, *Yeast* and *Euglena* are all such organisms (Figure 13.5). They look very different. Their structure is suited to their habitat. For example, both *Chlamydomonas* and *Paramecium* live in water. So they have special hair like or whip structures (*cilia* and *flagella*) to swim around.

Most of the living bodies we see around us are made of many cells. There are some organisms which are actually a



group of cells living together (*colony*)  
Most multicellular organisms have cells formed into tissues for performing various functions.

### Activity 2

- (i) Observe a drop of pond water under the microscope. Note down the shapes and relative sizes of the organisms. Do they all swim?
- (ii) Observe the drop under the microscope on a slide and locate a paramecium. Transfer some paramecia with the help of an ink dropper into another container for seven days and then take a drop from this on a glass slide under the microscope. Note down if you can see only single cells or dividing paramecium also.

### ANSWER THESE

1. State whether the statements below are true or false. Also correct the false statements.
  - (i) All living organisms are made of cells.
  - (ii) All living organisms are made of many cells.
  - (iii) An amoeba can do all the tasks that a human being can do.
  - (iv) All cells in a multicellular organism can live independently.

**Fig. 13.5** Some single-celled organisms:  
(a) Amoeba, (b) Euglena, (c) Paramecium, (d) Chlamydomonas and (e) yeast

2. Why are nerve cells long and have projections?
3. How do cells increase in number?

### 13.3 Tissues

The names of the tissues are usually given by the functions they do. So the cells that make up that tissue are also given the same name. Most of the organs in plants and animals are made of more than one kind of tissue. You may wonder how your heart and eyes can have the same tissue because they look so different and do such different jobs. The only difference is the way the tissues are organised in these two organs. The same is true of a leaf and a tree trunk. The same type of tissue acts as a protective cover for the leaf and the tree trunk. Sometimes the structures of the tissues differ a little because of their function. The tissue which covers the lower surface of a leaf has some pores (*stoma*) which can be opened and closed depending on the moisture content and exchange of gases (Figure 13.6). The opening and the closing of the pore is controlled by guard cells in the tissue layer of the lower surface. These are not present on the upper cover of the leaf or on the cover of the trunk.

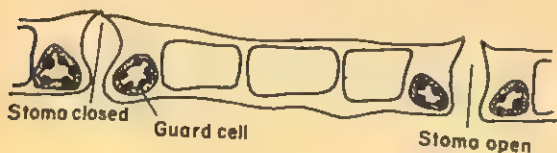


Fig. 13.6 The Lower Cover of a Leaf showing Closed and Open Stomata. Compare this with Figure 13.1.

### (A) PLANT TISSUES

There are mainly four kinds of tissues in plants.

If you soak mustard seeds overnight in water and keep them on a wet cloth or paper you can see small white sprouts come out in a day (Fig. 13.7 a). You will

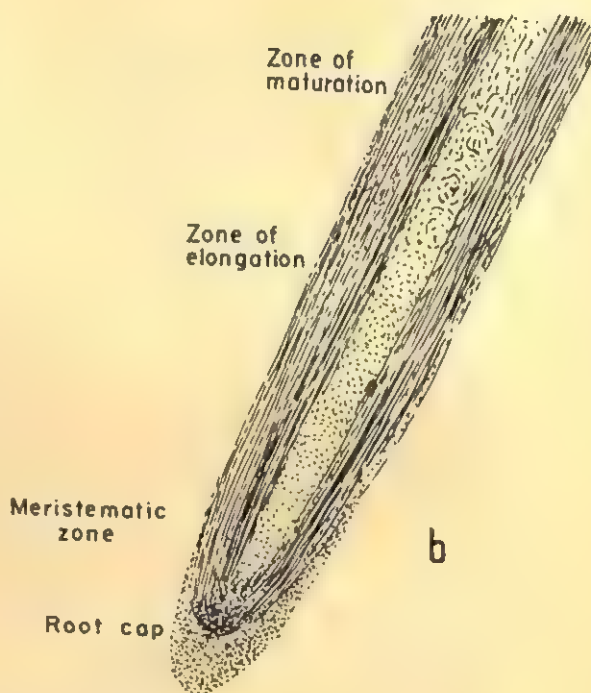
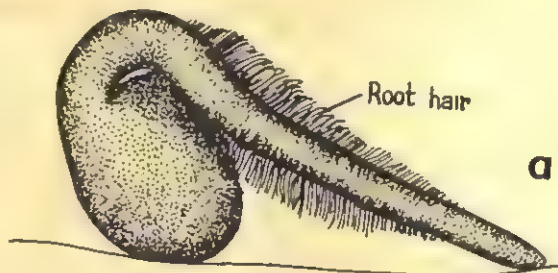


Fig. 13.7 Plant Tissues: (a) Sprout of a Mustard Seed, (b) Root with some details

notice that they grow quite fast. At this stage of growth of the plant there is only one type of tissue. The cells in this tissue divide rapidly and help in the fast growth of the plant. This tissue is called the *meristematic* tissue. The cells in this tissue divide continuously. They are located mainly at the tips of the sprouts. Some of these cells which are not at the tips become specialised and do not divide anymore. Some remain the same and help in growth of the plant. Those cells which stop dividing make three types of tissue. These three types of tissues are called *dermal* (skin-like), *vascular* and *ground* tissues.

Figure 13.7 b shows the tips of the root. Here the actively dividing meristematic tissue increases the length of the root at the tip. These cells begin to turn into the other tissue types further up the root (zone of specialisation). The thickness of the stem also increases with time due to the active cell division of the meristematic tissue. The cells of this tissue are round or elongated.

### *Dermal Tissue*

This tissue forms the outermost covering of all the parts of the plant. The term *dermal* comes from the Greek word for skin. The stem, root, leaves, flowers, fruit and seeds all have a surface cover made of dermal tissue. This tissue protects the plants, reduces the evaporation of water, exchanges gases like oxygen, carbon dioxide and water vapour from the air. In roots dermal tissue also

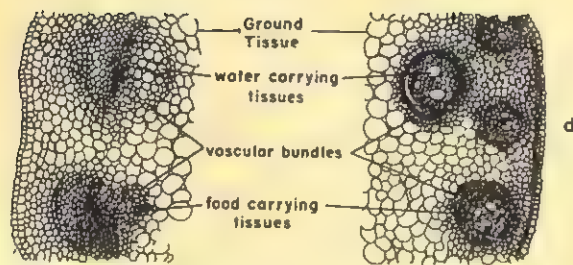
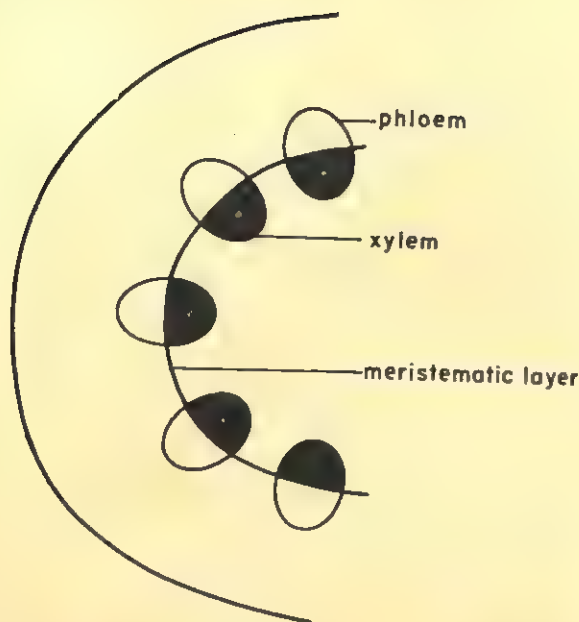
helps in absorption of water from soil.

### *Activity 3*

Observe the seedlings of green gram, mustard seeds or Bengal gram under a microscope or with a hand magnifying glass. You will see fine hairs on the roots. These are projections from the epidermal cells of the root. These absorb water and minerals from the environment. Fig. 13.7a shows the root hairs in mustard sprouts.

### *Vascular Tissues*

These tissues transport water, minerals and food to different parts of the plant. The term *vascular* in Latin refers to tubes and vessels that transport liquids. The root of the plant absorbs water and minerals from the soil. These nutrients are transported up to the leaves. The food prepared in the leaves is then transported to the different parts of the body. The tissue which carries water and minerals to the leaves is called *xylem*. The word *xylem* is derived from the Greek word for wood. The tissue which carries the prepared food from the leaves to other parts is called the *phloem* (derived from the Greek word for bark). Figure 13.7c shows a young woody stem. Here the meristematic tissue gives rise to phloem and xylem cells. The cells of the xylem are thick-walled, tubular and often dead. The phloem cells are tubular. Sometimes the cells in these tissues occur in a bunch called *vascular bundle*.



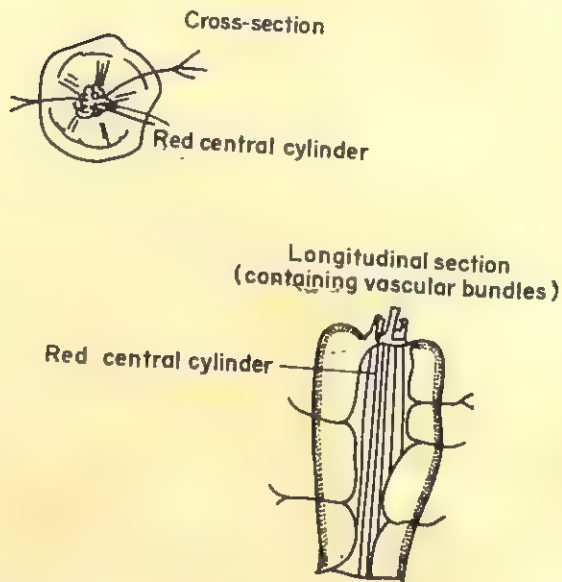
**Fig. 13.7.** (c) Young woody stem with Xylem, Phloem and the Meristematic layer and (d) the organisation of the Xylem, Phloem and the vascular bundles.

(Fig. 13.7d). They also give some mechanical support to the stems and leaves.

#### Activity 4

- (i) Take a carrot and cut off its lower tip. Then place it in red ink and water solution for several hours. Take it out and cut a thin piece horizontally and one vertically. You

will observe the red colour in the central cylinder. The xylem cells transport the ink upwards (Fig. 13.8).



**Fig. 13.8** Cross-sectional and longitudinal sectional view of a Carrot Cell Organization. Xylem transports the ink.

- (ii) Take a small branch with flowers having white petals. Take a small container and put some water and red ink in it. Place the branch in this and leave for two hours. Then you will notice that the white petals have turned pink and red. This shows that water moves upwards through the stem to the leaves and flowers.

#### Ground Tissues

These tissues provide mechanical sup-

port to the plants. They are found in all parts of the plant—roots, stems, leaves and flowers. In green leaves the ground tissue helps in photosynthesis. The cells of this tissue are of various sizes and shapes. Many of these cells have thin walls while others have highly thickened walls. The *cortex* in woody stems is this type of tissue. Also the food-making layer in Figure 13.1 is made of this tissue.

### Activity 5

Take a thin section of a stem. Observe it under the microscope. You would see the ground tissue surrounding the vascular bundles (Fig. 13.7d).

### (B) ANIMAL TISSUES

In the animal world, most multicellular organisms are made of four basic types of tissue. Here again the structure of each tissue varies depending on its position in the body and its function.

#### *Epithelial Tissue*

Epithelial tissue covers the entire surface of our body and the lining of the organs. The outer surface of the skin and the inner surfaces of the mouth, oesophagus, stomach, intestine and lungs are all made of epithelial tissue. Epithelial cells have different shapes depending on their location and function. They could be flat, or tall like a column. In the epithelial tissue the individual cells are tightly packed. This arrangement of cells in the epithelial tissue makes it an excellent protective tissue. Some epithelial cells also perform some additional functions.

For example, the epithelial cells lining the stomach secrete juices to digest food. Epithelial cells in the intestine help to absorb the digested food. In the skin, epithelial cells help in the removal of waste as sweat. Figure 13.9 shows different kinds of epithelial cells.

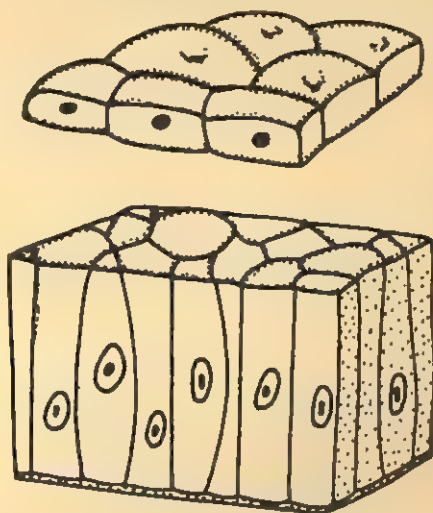


Fig. 13.9 Two different types of arrangements of cells in epithelial tissues

#### *Muscular Tissue*

Muscle cells are long and cylindrical in shape. The muscular tissue is just a bundle of such cells. The cells can contract and expand, this is why muscular tissue occurs in every part of the body where movement is involved. For example, the heart, which expands and contracts regularly, is largely made of muscular tissue. The muscles of our legs and hands are also made of this tissue. The muscular tissue gives the

stomach, intestine and urinary bladder the ability to move (contractions and expansions). Figure 13.10 shows different types of muscular tissues.



Fig. 13.10 Two kinds of muscle tissue

### Nervous Tissue

The cells of the nervous tissue have a cell body and a long tail (axon) as shown in Figure 13.11. These long cells form the

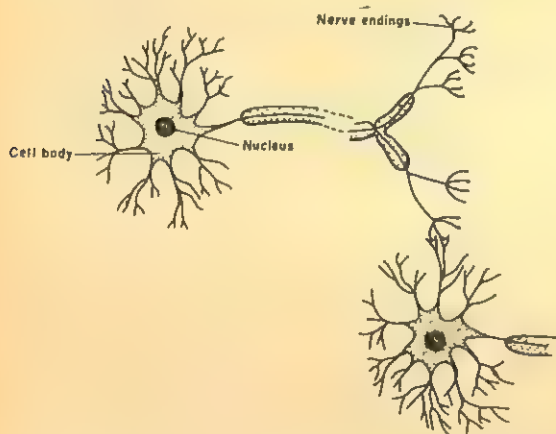


Fig. 13.11 Nerve cells joined end to end to form long nerve fibres

nervous tissue. These cells are joined end to end to form long nerve fibres. Such fibres conduct messages from one part of the body to the other. The brain and the spinal cord are made up of the nervous tissue.

### Connective Tissue

You have noticed that all the tissues we have seen till now are made of cells packed tightly together. This feature is absent in the connective tissue. This tissue is made up of cells separated from each other. The space between the cells is composed of different substances. For example, in the bone the space between the cells is full of calcium and other minerals. This makes our bones hard. In the blood the space between the cells is filled with a liquid called the blood plasma and this makes our blood fluid. The main function of connective tissue is to form a support for our body as the bones and cartilages do or transport materials from one part of the body to the other as the blood does. Figure 13.12 shows some connective tissues.

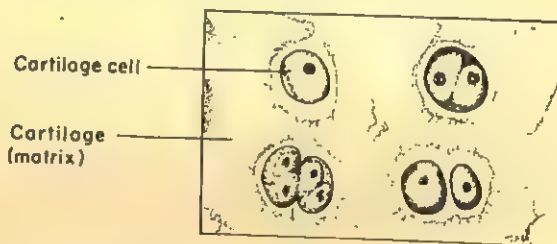


Fig. 13.12 Connective tissues

Almost every organ in the human body is made of all the four kinds of tissues. The same is true of plants. The amount of each tissue in each organ varies a lot depending on its function. The large trunk of a banyan tree has much more cortex tissue (a type of ground tissue) than the thin stem of

maize. Nervous tissue is not present in all animals. The hydra has very few nerve cells, but our brain and spinal cord are mainly made of nervous tissue. Our heart has a lot of muscular tissue since it has to expand and contract regularly. Our movement is performed by both muscular and connective tissue which are present in muscles, bones and cartilages. But the insects use only muscular tissue for movement. So the multicellular living world uses combination of these basic tissues in order to perform all the activities and to keep themselves *alive*.

#### ANSWER THESE

1. Match the following:

Mango peel	Ground tissue
Cambium	Dermal tissue
Phloem	Meristematic tissue

Photosynthetic cells	Vascular tissue
----------------------	-----------------

2. Which tissue is responsible for growth of roots?
3. What are the tissues in the leaf? Which tissue helps in controlling moisture in the leaf?

#### YOU NOW KNOW

- Most living bodies have a definite organisation to function as individuals.
- There are three levels of organisation in complex multicellular organisms: organs or organ-systems, tissues and cells. Cells make tissues, and tissues

make organs. A combination of organs is called an organ system.

- All living beings are made of cells of different shapes and sizes.
- Some organisms are made of a single cell which can perform all basic functions to keep alive.
- Some organisms are made of many cells where different cells or clusters of cells do specialized functions.
- Plants are made of four different kinds of tissues. They are meristematic, ground, dermal and vascular. All organs like leaf and flowers are made of these.
- Animal organs are made of mainly four kinds of tissues. These are epithelial, muscular, connective and nervous tissues. All organs like stomach, heart, kidney, eyes are made of these.

#### NOW ANSWER THESE

1. What are the various levels of organisation of a multicellular organism? Give two examples of each.
2. What are the functions of a leaf? What kind of tissues are present in the leaf?
3. What are the largest and smallest cells in human body? The nerve cells have projections. Why?
4. Take four examples and show that the structure of the cells and tissues are important for their functions.

5. Which one term in each includes the other three?

- (i) Tissue, cell, organ, nucleus.
- (ii) Vascular bundles, cortex, cambium, stem.
- (iii) Muscles, hand, skin, bones.
- (iv) Nucleus, cytoplasm, cell, membrane.

6. Fill in the blanks:

- (i) A group of cells similar in size and shape, performing a function together is called a \_\_\_\_\_
- (ii) A group of different \_\_\_\_\_ working together to perform a function is called an organ.
- (iii) A single-celled animal of ever-changing shape is the \_\_\_\_\_
- (iv) What is a \_\_\_\_\_ to an organism, as a brick is to a house.

7. Match the items in the two columns.

Stomach	Structural and functional unit of life
Food	Multicellular organism
Cell	Animal tissue
Nervous tissue	Organ
Hydra	Energy

8. State whether each of these statements is correct or false. Correct the false ones.

- (i) The structure of the tissue depends on its function.
- (ii) Your skin, mango peel and the top layer of the leaf are made of the same tissue.
- (iii) Meristematic tissue is responsible for growth in animals.
- (iv) The epithelial tissue is responsible for growth in animals.
- (v) In humans, movement only involves muscular tissue.

## CHAPTER FOURTEEN

### Life Processes-I

WE KNOW that all living organisms, however different they look, perform some basic functions to keep themselves alive. These basic activities which allow life to continue on earth are known as *life processes*. The basic life processes common to all living organisms are nutrition, respiration, excretion, response to stimuli, growth and reproduction. The two processes *nutrition* and *respiration* give energy. *Excretion* involves throwing off waste materials accumulated in the body. *Reaction to stimuli* is a process which helps organisms to survive in changing environment. It also helps in doing all the functions in an ordered manner. *Growth and reproduction* are processes which help them continue on this earth by making more of their kinds. You will read in this chapter how both simple and complex organisms do these functions. Depending on their structure and habitat they use different methods to perform these functions.

#### 14.1 Energy is Needed for the Life Processes

Living organisms require energy to perform the life processes. They use

chemical energy for doing any work and this energy is obtained from chemical reactions. Here food is the fuel. But to get chemical energy from food it has to be broken into smaller and soluble molecules. The whole process of nutrition involves taking in bulk food and converting it into smaller molecules. These smaller molecules can then take part in chemical reactions. These reactions use oxygen to *burn* these molecules. Respiration provides oxygen to the cells and releases energy. The energy obtained in this process is stored in other molecules in the cells. The cells use this energy when they need for other life processes. Since food is the basic requirement for energy, we will first learn how different organisms get their food.

#### 14.2 Modes of Procuring Food

##### (A) GREEN PLANTS MAKE THEIR OWN FOOD

You know that all green plants are *autotrophs* because they can make their own food from the inorganic substances in the environment.

The leaves (and stems sometimes)

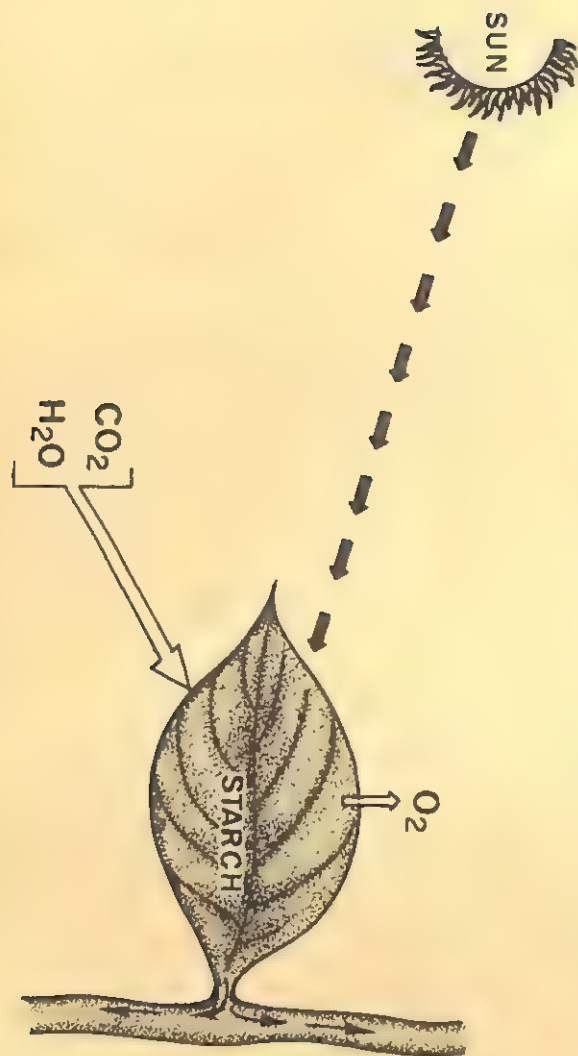


Fig. 14. 1 Green leaves make carbohydrate and oxygen from carbon dioxide and water using sunlight. This reaction is called *photosynthesis*.

are green because the cells contain bodies called *chloroplasts*. These have green-coloured material (*pigments*) called *chlorophyll*. The green plants use chlorophyll to trap energy from sunlight. They synthesise an organic compound called *carbohydrate* using

carbon dioxide and water from the environment and energy from sunlight. Oxygen is released in the process. This process of making food in the green plants is known as *photosynthesis*. This food is then distributed from the leaves to different parts of the plant. Figure 14.1 shows the process schematically. Here, the green plants convert the energy from sunlight to chemical energy by making carbohydrate.

### Activity 1

#### TEACHER DEMONSTRATION

Take any potted plant (or young plant in the garden), piece of aluminium foil (cigarette folder), iodine, alcohol, water, two hard glass beakers for boiling (double boiler) and a gas stove (or a bunsen burner).

Cover a part of a leaf with aluminium foil in one plant. Place the pot in sunlight for three or four days. Remove the leaf and the foil from it. Place one pot with water on the stove to boil. Put the other part with some alcohol and the leaf on the top of the boiling water pot. (see Figure 14.2). *Caution:* Never try boiling alcohol directly over the flame. The fumes will catch fire.

On boiling the chlorophyll will be extracted from the leaf and the alcohol turns green. The leaf goes pale when washed with warm water. Now add a few drops of iodine solution on the leaves. The part of the leaf exposed to sunlight turns blue-black, whereas the covered part does not. Iodine turns blue-black on

### Leaf exposed to sunlight

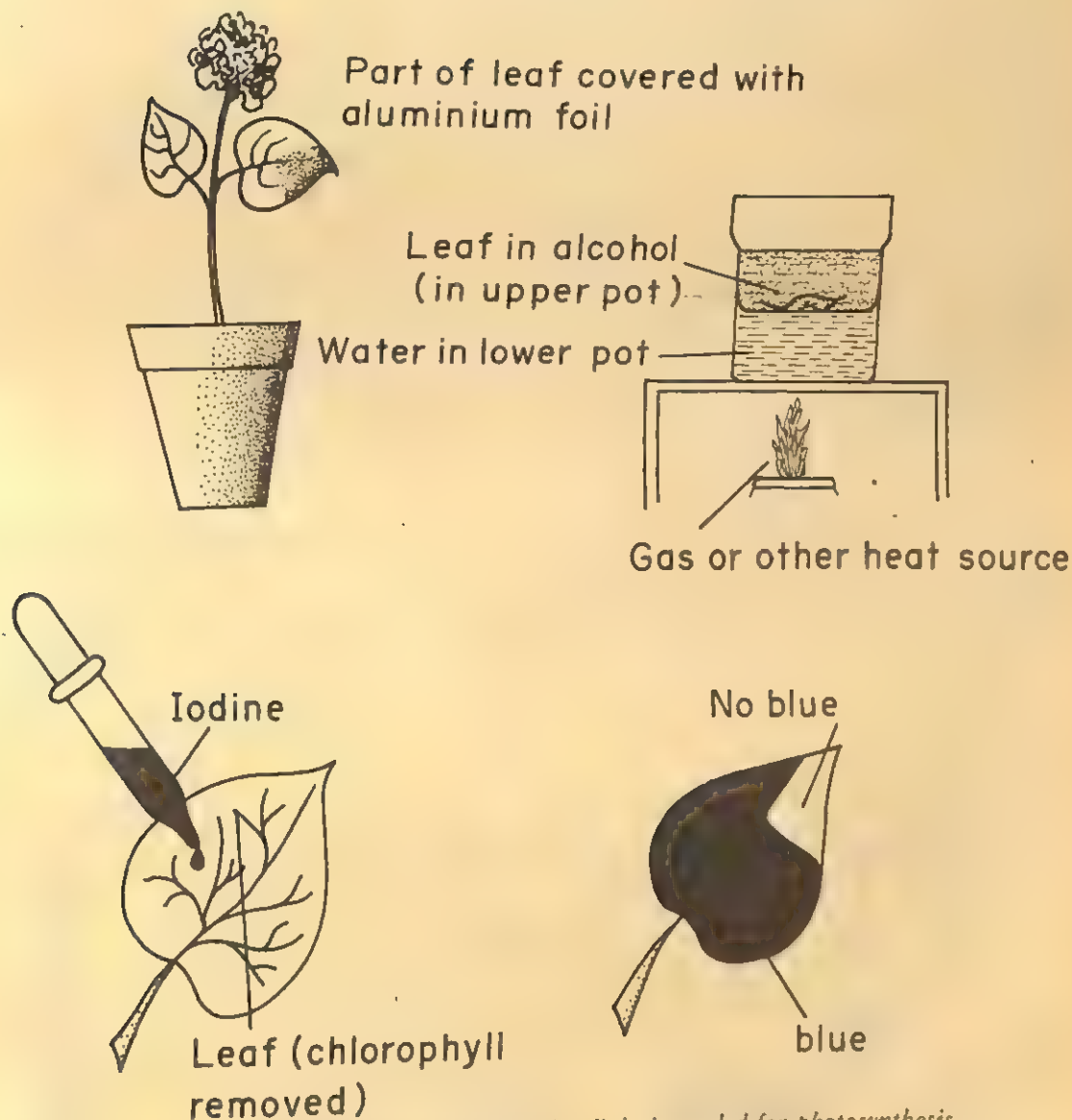


Fig. 14. 2 Experimental design to show that light is needed for photosynthesis

reacting with starch. So we conclude that:

(i) Sunlight is necessary in the process

of photosynthesis, and  
(ii) Leaves make starch as food by photosynthesis.

### Activity 2

Select a plant whose leaves are partly green and partly white (variegated) such as croton or coleus. Do the rest of the experiment as in Activity 1. Write down how you will do this experiment and conclude as you see.

*Note:* You will observe that the white part does not turn blue with iodine, whereas the green parts do. So the conclusion is that chlorophyll is necessary for photosynthesis.

### (B) OTHER ORGANISMS DEPEND ON READY-MADE FOOD

All non-green plants and animals are *heterotrophs*. They get their food from other plants and animals. If you list all the things that you eat during the day, you will know how much we all depend on other plants and animals. For rice, wheat, pulses (*dals*), fruits and vegetables,

we depend on many plants. For milk, curd, cheese and eggs, we depend on animals. Many people also eat meat, fish and chicken. Same is true for many other organisms such as fish, birds, snakes and insects. Do you know even plants can eat insects? The pitcher plant and the venus-fly-trap are plants which eat insects. All animals are divided on the basis of their eating habits as *herbivores* (plant eaters), *carnivores* (meat eaters) and *omnivores* (those who eat both plants and animals). Figure 14.3 shows how all living beings on earth depend on the sun, whose energy is converted to food by the green plants.

### (C) OBTAINING FOOD BY DIFFERENT METHODS

Different organisms use different methods to get food. There are special structures in each organism for taking food in.

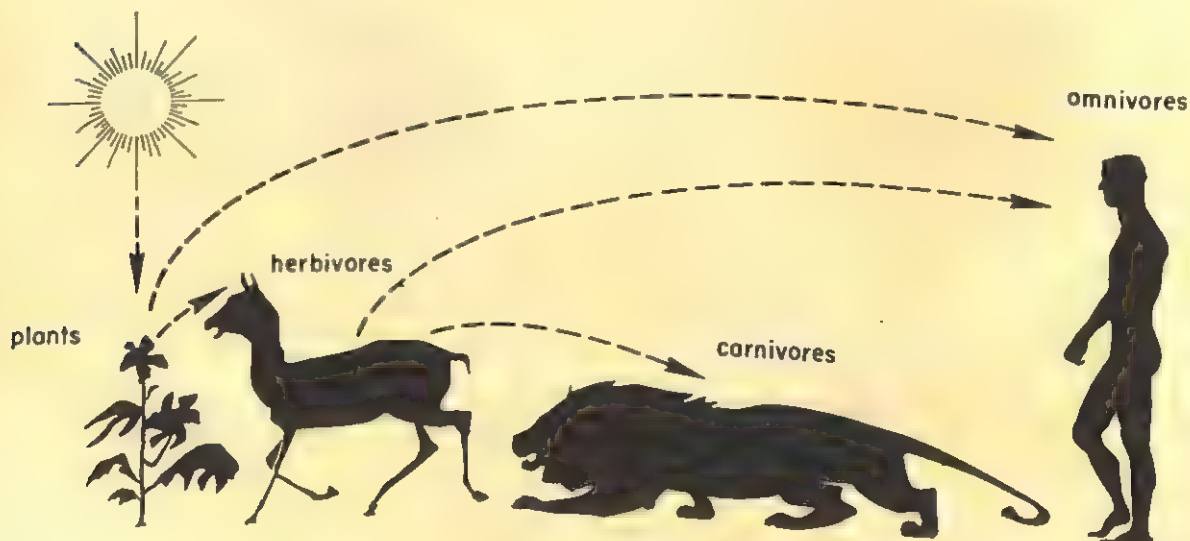


Fig. 14. 3 Living beings in the world depend on the sun.

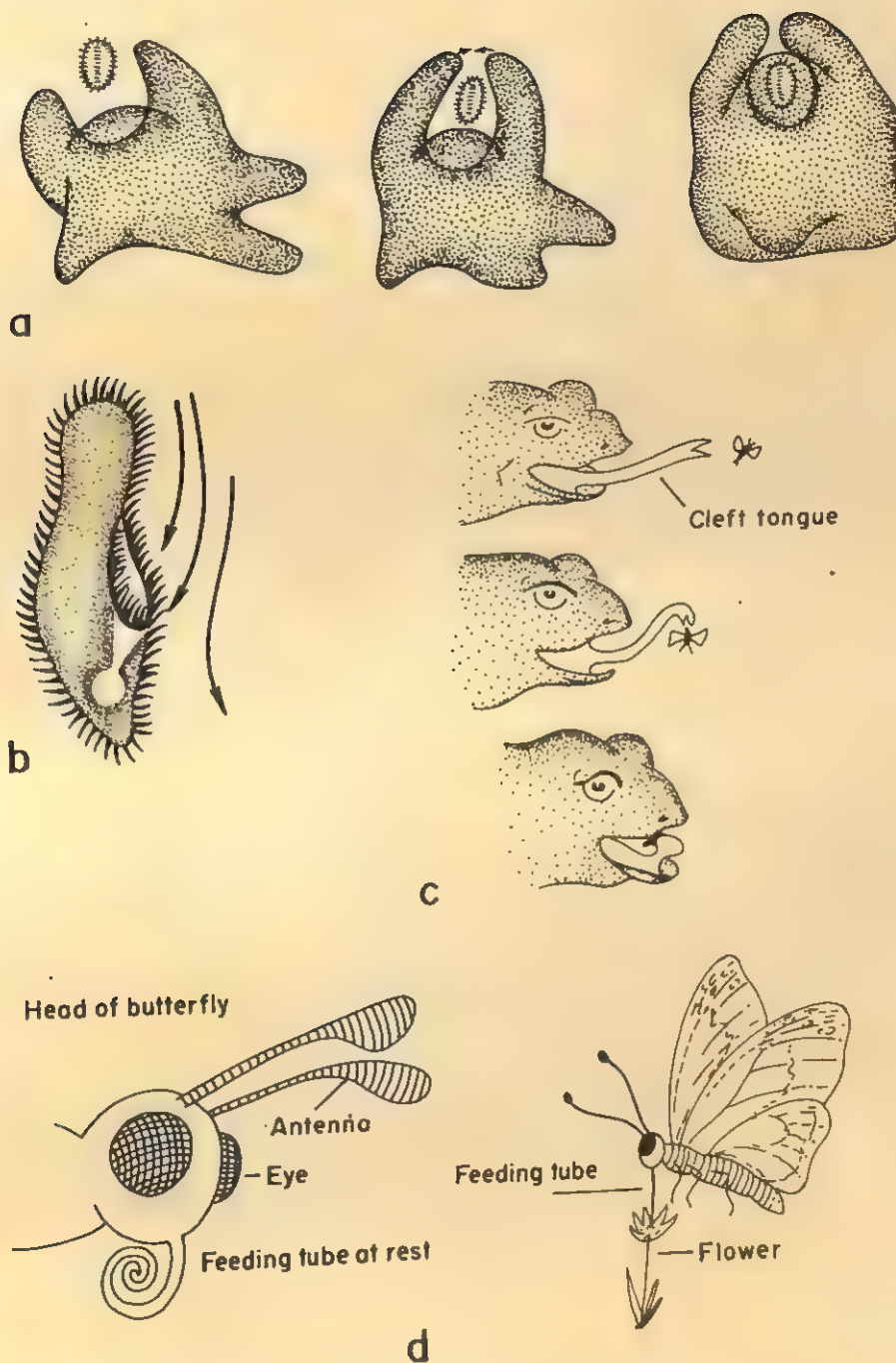


Fig. 14. 4 How some organisms obtain and eat their food

Figure 14.4 shows some organisms and their mode of getting food. Amoebae use their false feet (pseudopodia) to engulf the food particle. A paramecium has brush-like body structures (cilia) to sweep food particles from water into them. The frog uses its tongue to catch its prey. The butterfly uses its feeding tube to suck the nectar. Hydra use tentacles with sting cells to kill the prey and put into their body cavities. A spider weaves web to catch its prey. We use our hands to put food in our mouth. You can see how many different methods there are in nature for procuring food.

#### Activity 4

List all animals you see around and classify them as herbivores and carnivores. Also record how they procure their food. List at least five animals which are omnivores.

### 14.3 Different Steps in the Process of Nutrition

You have seen how the modes of getting food vary in nature. The acts of getting and eating food are the first two steps of the process of nutrition in animals called *ingestion*. But to get energy for the life processes this bulk food is to be then converted into smaller molecules. This process is known as *digestion*. Most animals use both physical and chemical methods for

#### Activity 3

Watch and note down how the following organisms get their food: (i) ant, (ii) crow, (iii) wall lizard.

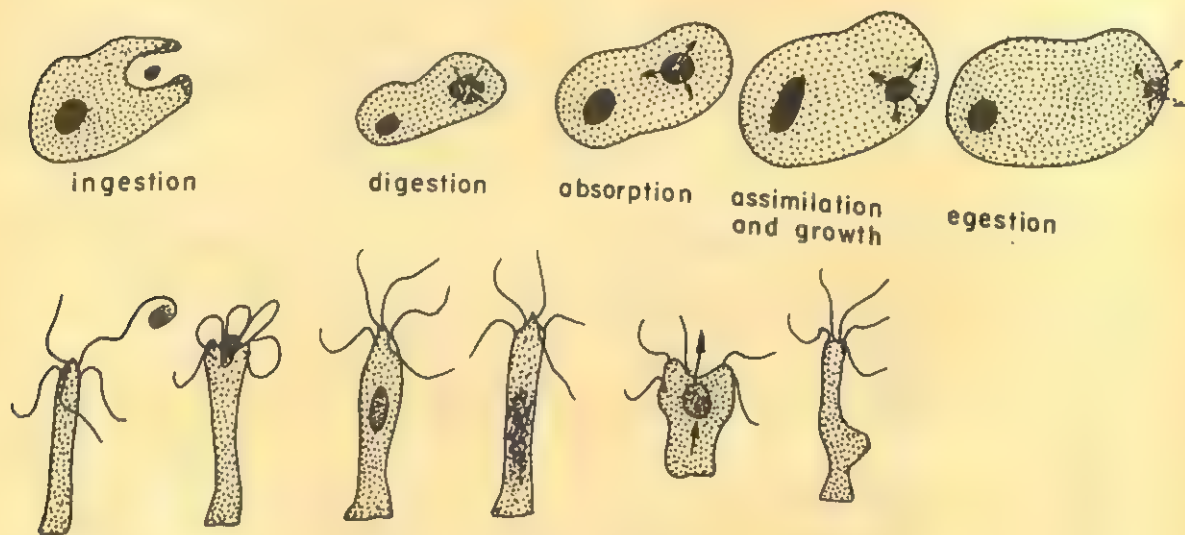


Fig. 14. 5 The process of nutrition in an amoeba (top) and in a hydra (bottom)

breaking up the food molecules. The digested nutrients are then taken into different parts of the body by the blood circulatory system. The cells in the body then absorb these digested food molecules. Finally this absorbed material is used in the cells for producing energy and for growth. This process is known as *assimilation*. The remaining undigested substances are excreted by the process of *egestion*.

All these processes are also performed by the single cell organism, amoeba. Here digestion is chemical and performed by enzymes. Enzymes are special molecules in cells. They help in breaking down food into simpler molecules through chemical reactions. On assimilating the food the amoeba grows in size and then divides into two daughter cells. Figure 14.5 shows this whole process in amoeba and hydra. In *Hydra*, the tentacles help in ingesting the food. The cells inside the cavity wall secrete chemicals to digest the food. The digested food is absorbed by diffusion through the cavity walls and assimilated in the cells. On eating food the hydra grows and reproduces by forming buds.

In more complex multicellular animals such as the fish, frog and human, all these processes in nutrition are performed by specific organs and organ systems. Figure 14.6 shows such organs in humans. It is interesting to know that with us digestion begins in the mouth itself. The teeth help in breaking bulk food in smaller pieces by chewing, and

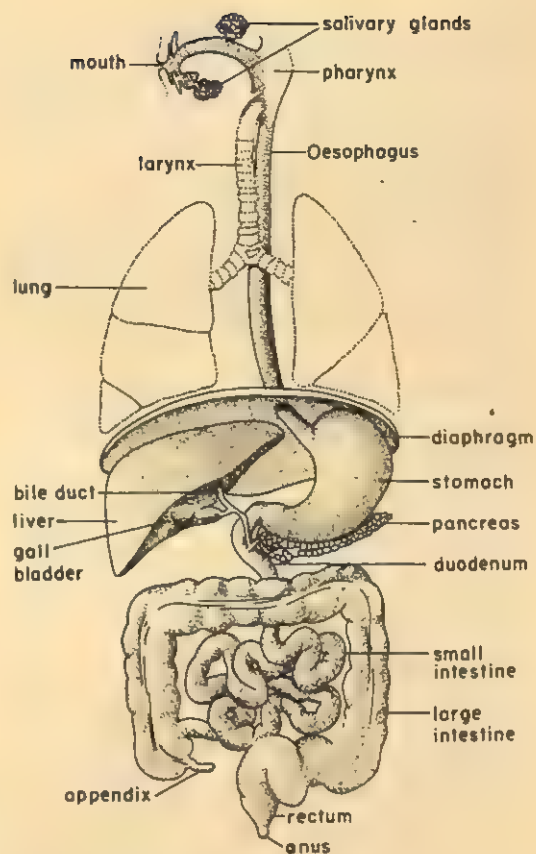


Fig. 14. 6 Digestive Organs of the Human Body

the tongue helps in mixing saliva with food. The enzymes in saliva help in chemical digestion. Then food enters the food pipe (*oesophagus*), its wall starts contraction and expansion movement. This is called *peristaltic* movement that pumps the food into the stomach. Digestion continues in stomach and the small intestine with the help of digestive enzymes. The small intestine is the main region for absorption of digested food. It is about 20 feet long. The inner surface

has many finger-like projections called *villi*. These structures offer a large area that aids in the absorption of food. This absorbed food is then carried by blood to all other parts of the body. Water in the undigested food is absorbed by the walls of the large intestine. The remaining undigested and unabsorbed food is thrown out through anus as faeces.

#### ANSWER THESE

1. Fill in the blanks :
  - (i) All living organisms use \_\_\_\_\_ to perform life processes.
  - (ii) Green plants use \_\_\_\_\_ and \_\_\_\_\_ to make food.
  - (iii) Heterotrophs depend on other \_\_\_\_\_ and \_\_\_\_\_ for food.
  - (iv) The five steps in the process of nutrition are \_\_\_\_\_, \_\_\_\_\_, absorption, \_\_\_\_\_ and \_\_\_\_\_.
2. Which of the organs perform the following functions in humans?
  - (i) Digestion (ii) Absorption of food
  - (iii) Absorption of water.

#### 14.4 Respiration

The assimilated food is used for two processes. First, it is used for the growth of the body. Secondly, it is used as a fuel to get the energy necessary for other life processes. The second process needs oxygen. This oxygen is used in the cells for chemical reactions with molecules obtained from the digested food. These

reactions release energy which is stored in some special molecules. This process of taking oxygen into the cells, using it for energy release and then eliminating the waste products ( $\text{CO}_2$  and water vapour) is known as respiration.

#### HOW DO WE GET OXYGEN CONTINUOUSLY?

You know that animals take oxygen from the environment and return  $\text{CO}_2$ . If oxygen gets used up like this, then how does it get replenished? Remember what happens during photosynthesis. The leaves take  $\text{CO}_2$  and convert it into starch. They release oxygen to the atmosphere. This process keeps the supply of  $\text{O}_2$  in the atmosphere adequate for respiration. So photosynthesis in plants is very important for three reasons: (1) it makes food for plants themselves, (2) it is a source of food for heterotrophs, and (3) it keeps the oxygen and  $\text{CO}_2$  content in the atmosphere in right amounts for our survival.

#### DIFFERENT MODES OF RESPIRATION

There are two main parts in the process of respiration: (i) breathing, that is intake of oxygen and releasing  $\text{CO}_2$ , and (ii) using oxygen in the cells for releasing energy. Different organisms have different methods of doing them. Amoeba or planaria depend on simple

diffusion of gases for breathing. In complex multicellular animals such as fish, frog and humans, the breathing organs differ widely. We all breathe through our nose. Can you do that inside water when you are swimming or diving? You cannot, and so the divers have to wear oxygen masks when they go under the sea. Fishes and many other aquatic animals have a special organ called the gill. Here the dissolved oxygen is extracted from the water that passes through this organ. Earthworms and leeches absorb the atmospheric oxygen through their moist skin. Grasshopper gets oxygen through holes and airtubes in its body. In all the cases  $\text{CO}_2$  goes out by the same way. In plants, the exchange of gases occurs through pores in the leaves and stems. These are called *stomata* and *lenticels*. They allow oxygen,  $\text{CO}_2$  and water vapour to enter or leave the tissues by diffusion.

### *Respiration in Humans*

In humans several organs take part in the process of respiration. Figure 14.6 also shows the organs of respiration. The air containing oxygen is taken in through the nose and passed through the *larynx* to the chest region. Here the tube divides into two branches which enter the left and right lungs. In the lungs, air passes through a large number of small branches and finally reaches thin walled cavities or air sacks known as *alveoli*. Have you noticed how chest goes up and down or heaves as you breathe in and

out? This expansion and compression movement of the chest cavity helps in sucking in  $\text{O}_2$  and squeezing out  $\text{CO}_2$  from the walls of the lungs.

The wall of the alveoli has a large number of very thin tubes or blood capillaries. Oxygen of the air diffuses into the blood. Carbon dioxide diffuses out from the blood into the lung cavity. Blood is the carrier of oxygen to the cells in different parts of the body. It contains a type of cells called *red blood cells* which carry  $\text{O}_2$  in them. It is red because of a pigment called *haemoglobin*. Haemoglobin carries oxygen. Oxygen diffuses to the cells as blood passes through tissues. Blood also collects  $\text{CO}_2$  and its compounds and water from tissues and carries it to the lungs for breathing out. All these organs and tissues complete the process of gas exchange in respiration.

### *Activity 5*

Count how many times you breathe per minute (i) at rest, and (ii) after doing a 20 sit-up exercise. Compare your results with those of your friends. You will notice that the breathing rate goes up with exercise. When you exercise, your body needs more energy and, therefore, more oxygen.

### *Activity 6*

Take a beaker half-full of lime water  $\text{Ca}(\text{OH})_2$ . Breathe out to the lime water. What do you see? The lime water turns milky. This shows that you breathe out  $\text{CO}_2$  which makes the lime water milky

(due to the formation of  $\text{CaCO}_3$ )

### Cellular Respiration

Energy is produced in the cells when chemical reactions break down molecules obtained from food in presence of oxygen. This process is known as *cellular respiration* and is common to all organisms. The molecule that is used as a fuel is sugar. It is finally oxidised to carbon dioxide and water. Does it seem similar to burning or combustion? It is, but there are many differences. A few differences are given in Table 14.1

TABLE 14.1

Respiration Differs from Combustion

Respiration	Combustion
Happens at ordinary temperature ( $37^\circ\text{C}$ )	Needs high temperature
Slow process	Fast process
Many steps involved in the breakdown of fuel	Converts fuel directly to $\text{CO}_2$ and water
The energy is always stored in a chemical molecule	Energy is obtained in different forms such as heat and light.

A byproduct of cellular respiration is carbon dioxide. This is released from the cells to the blood as gas and compounds of carbon dioxide. In the lungs the gaseous form is released which is breathed out.

You know that we and many other organisms use oxygen for respiration. Plants also do the same. It is only during day time that plants use  $\text{CO}_2$  in photosynthesis and  $\text{O}_2$  in respiration. But at night time only respiration takes place and they release  $\text{CO}_2$  like us. So many people believe that it is not good to sleep under a tree at night. It is true that  $\text{CO}_2$  concentration may go up under the tree, but it gets mixed with the environment easily and so may not prove harmful. In fact, it is very dangerous to sleep in a closed room with an oil lamp on. This reduces the  $\text{O}_2$  and increases the  $\text{CO}_2$  concentration in the room and can cause difficulty in respiration (*suffocation*).

Fig. 14. 7 Plants and animals depend on each other for their survival.



Look at figure 14.7 showing three bell-jars kept in a sunlit place. The bell-jars are tightly closed by grease so that no air can pass through. You would notice that in the first and second jars (which have a potted plant and a grasshopper) the plant has drooped and the insect is suffocated, whereas in the third jar both survive longer together. Why does this happen? In the two bell-jars the air in the jars gets depleted of oxygen and  $\text{CO}_2$  soon so the organisms droop. But in bell-jar on the right photosynthesis in the plant gives  $\text{O}_2$  to the grasshopper for its respiration to continue. And the grasshopper's respiration returns  $\text{CO}_2$  to the plant for its photosynthesis.

There are some organisms like yeast and some bacteria which can live without oxygen. They release energy by breaking down glucose into ethyl alcohol and carbon dioxide in the cells. This process is called *anaerobic respiration* or *fermentation*.

#### ANSWER THESE

1. Are the following statements correct?
  - (i) During respiration the plants take  $\text{CO}_2$  and release  $\text{O}_2$ .
  - (ii) Fish and earthworms exchange

gases during respiration in the same way.

- (iii) Blood in humans carries both  $\text{O}_2$  and some  $\text{CO}_2$ .
  - (iv) Respiration is a kind of combustion at ordinary temperatures.
  - (v) Energy can be produced in cells without oxygen.
2. What is the fuel for energy production in cells?
  3. What are the two main processes in respiration?

#### 14.5 Transport of Materials Inside the Body

Different materials such as nutrients and oxygen are required by different parts of the body to carry out various life processes. Even those which are produced in one part of the body must reach the parts where they are needed. Methods of transporting materials within the body are thus essential.

In single cell organisms e.g. amoeba and some simple organisms e.g. spirogyra materials move inside the body by diffusion and circulate along with the streaming of the cytoplasm. Diffusion is a slow process. To transport material to longer distances in a multicellular organism a faster process is required. If you want water to be carried from the river to an overhead tank, what all would you need? First a pipe or a vessel to carry the water and then pump or force to push it up. The same method is used for

transporting materials in complex plants and animals.

### TRANSPORT IN HIGHER PLANTS

In plants continuous transport of water, dissolved mineral salt, and food material goes on both upwards and downwards. You know that the vascular tissue acts as pipes or vessels in plants. This tissue contains xylem and phloem cells.

The xylem cells are mainly used for transporting water, mineral salts and minerals upwards from the roots through the stem to the leaves. Constant diffusion of water along with the minerals from the root cells produces a pushing force. At the same time constant evaporation of water (*transpiration*) from the leaves produces a pulling force

which causes the water to move upwards.

The phloem cells carry prepared food material in a soluble form from the leaves to the other parts of the body including the root. The driving force in phloem transport is generated by the individual cells or collection of cells in the vascular bundle.

Water moves upwards through channels in plants, leaves and roots. In tobacco plant the leaves have nicotine. An interesting experiment (Fig. 14.8) showed that nicotine is actually made in the roots and then transported to the leaves. One tomato plant and one tobacco plant were taken and divided into two parts. The stem portion of each plant were exchanged and grafted to the root

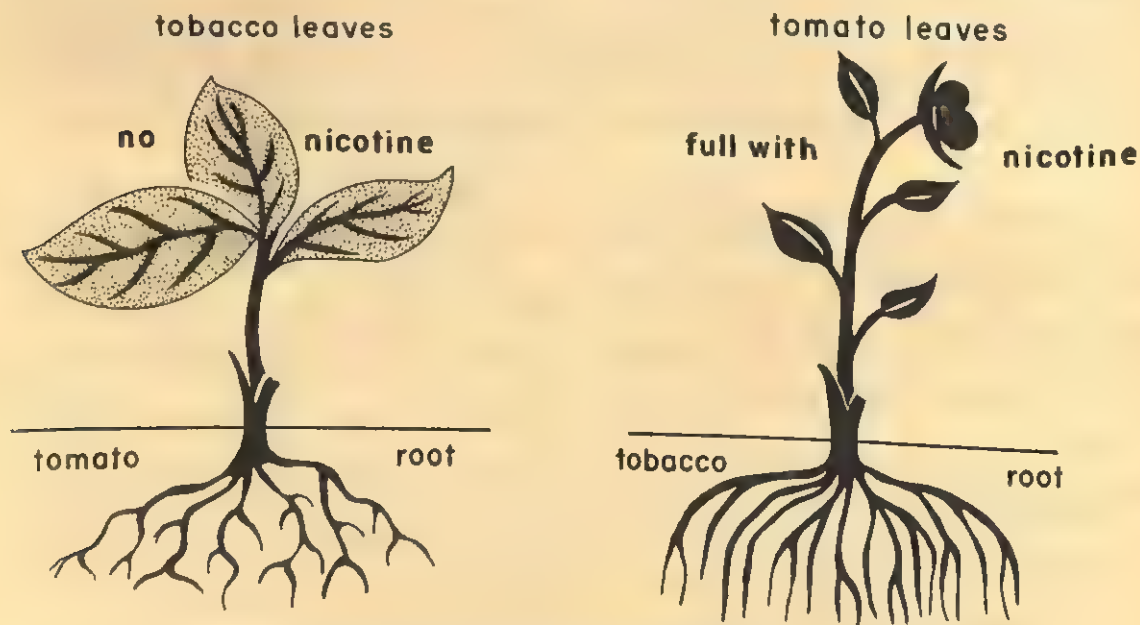


Fig. 14. 8 Transport of Nicotine from the Roots to the Leaves

portion of the other plant as shown in the figure. When these plants were grown it was found that there was no nicotine in the tobacco leaves which had the tomato root. But the tomato leaves were full with nicotine in the other graft. In many plants like potato, carrot and beetroot, the carbohydrates made in leaves are transported down to the roots and stored. This is what we eat as potatoes and carrots.

#### TRANSPORT IN HUMANS

In humans blood circulatory system is the major means of transport. Blood is the carrier of the food, air, waste and other necessary chemicals to all parts of the body. The circulatory system consists of the heart, arteries, veins, capillaries and blood. Here, the heart acts as the pump. Arteries, veins and capillaries are the pipes of different sizes and types. The heart is a triangular bag of thick muscular tissue. It has four chambers (*auricles* and *ventricles*) which connect to different arteries and veins. Arteries carry blood from the heart to all parts of the body. The veins carry blood from all parts of the body to the heart. A network of capillaries form the connection between the arteries and the veins. The heart pumps out blood to arteries about 70 times per minute. This periodic contraction and relaxation is called *heart beat*. You can feel the pumped wave of blood in the arteries by lightly pressing some of the arteries with your fingers. That is how the doctors feel your pulse.

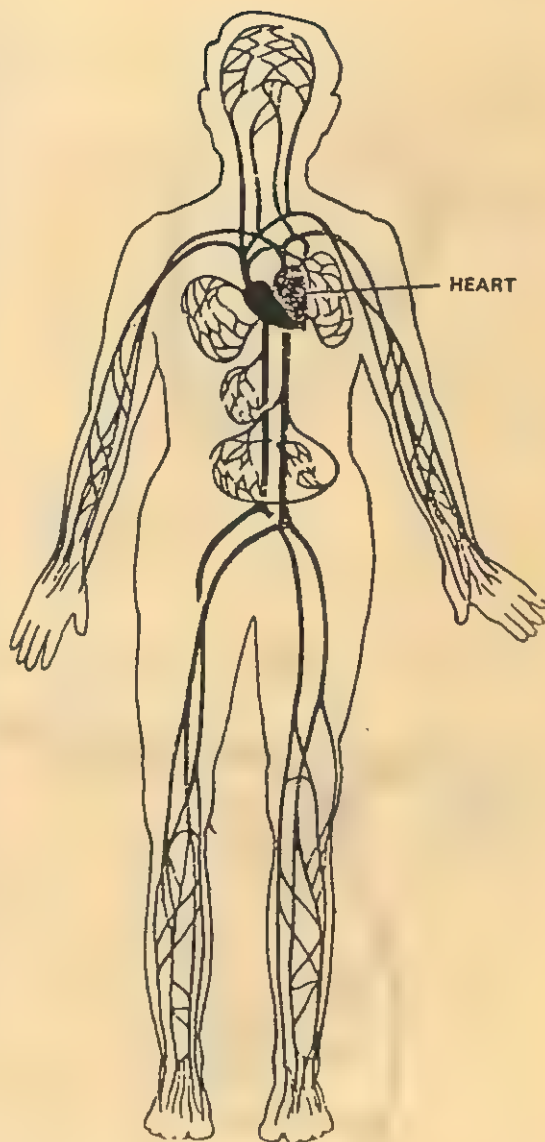


Fig. 14. 9 (a) Circulatory System

So heart beat can be counted by counting the pulse. For a better record the doctors use *stethoscope*. If you place this on the top of the heart region on your chest, you will be able to hear the beating of the heart.

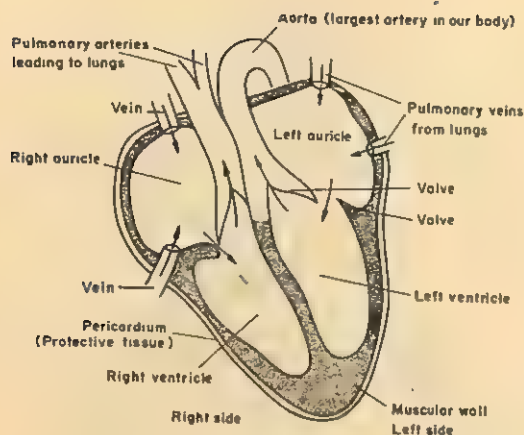


Fig. 14. 9 (b) the Human Heart. The arrows show the direction of blood flow.

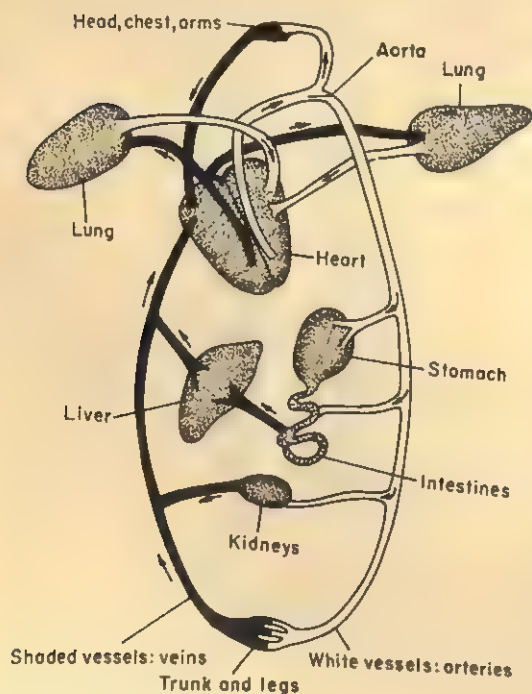


Fig. 14.10 Blood Circulation in the Human Body. The dark tubes or vessels are the veins and others are the arteries.

The heart is connected to the lungs where it pumps blood for oxygen and  $\text{CO}_2$  exchange. After distributing oxygen and other material to all parts of the body and collecting  $\text{CO}_2$  and other waste material, blood comes back to the heart and is then pumped back to the lungs. Figures 14.9 (b) and 14.10 show the picture of a heart and the different compartments and the main pipes connecting the heart and lungs.

Blood is a tissue that circulates in our body. It has many different cells which perform different functions. The red blood cells carry oxygen, the white blood cells help to fight against germs and other foreign bodies. There are other kinds of cells, such as platelets in the blood. All these cells are immersed in a fluid called the *plasma*. Plasma carries  $\text{CO}_2$  and many other substances. It also helps in the clotting of blood in a wound. Blood carries absorbed food from intestinal walls and different hormones from endocrine glands to different organs. There is also another fluid which helps in circulation. It is called *lymph*. It also plays a role in protecting the body against germs.

#### BLOOD TRANSFUSION

Blood is a very vital component of our body. In the case of serious injury, accident or during an operation we may lose considerable quantity of blood from our body. Some diseases and health conditions also affect blood formation.

This may result in blood deficiency or anaemia. In these cases blood from another healthy person is transferred to the deficient person. This is called *transfusion*. But the blood of all the persons falls in certain groups. Blood of some groups does not match with some others. If it does not match then it can be dangerous to the recipient. Therefore, we must check and record our blood groups so that delay can be avoided in case of an emergency.

### Activity 7

Press one of your nails or finger tips a little from the outer side. You would notice that it turns pale or white. Release the pressure, it becomes red. What happens? When you press, blood circulation stops and so it pales. The moment pressure is released blood rushes from the lower part of the finger and it looks red. This shows that red blood in arteries travels outwards to every part of the body.

### ANSWER THESE

- Match the words in the two columns:  
 Heart                      Pipes for transport in humans  
  
 Arteries and veins              Carrier of oxygen  
 Xylem cells              Water transport in plants  
  
 RBC                      Pumping organ
- Which cells carry water and food up and down in plants?

- What is heart beat? Does heart beat faster after exercise? Why?

### 14.6 Removal of Waste Products (Excretion)

When charcoal is burnt for cooking, it leaves some solid matter behind. Also  $\text{CO}_2$ , water and other gases are obtained. When you eat a banana you throw away the peel. When a house is built, there is always some material left over which is called "rubbish". These are called *waste products*. Life processes also yield some wastes. Respiration gives  $\text{CO}_2$  and water while digestion gives both solid and liquid wastes.

Since the waste products are not useful to the body, it is necessary to remove them. The process of waste removal is called *excretion*. The single cell organisms use the method of diffusion for waste removal. Plants have no specialised organs for this purpose but complex animals do. Waste material from the major life processes is removed by different methods.

### REMOVAL OF WASTE PRODUCTS IN HUMANS

Human beings have various organs to get rid of wastes (Fig.14.11). The respiratory wastes ( $\text{CO}_2$  and water) is removed by blood and eliminated through the lungs and the nose. The sweat glands in the skin eliminate urea, salt and excess water. Large intestine and its extensions eliminate some wastes with faeces. The kidneys excrete liquid waste as urine. Each kidney is a collection

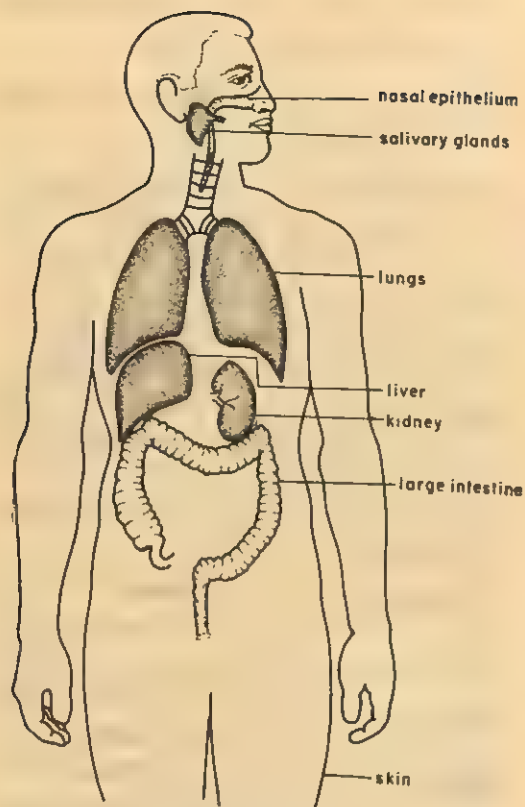


Fig. 14.11 Some of the Organs used by the Body for Waste Removal

of filters called *nephrons*. They have funnel-like structures which filter waste products from the blood. The outlets of all nephrons unite and join to form larger tubes. Finally all waste collects in the urinary bladder from which it is excreted regularly.

Waste removal is important for all living organisms. Normal kidney function is essential for good health. Examination of urine can give a good idea about the general health of the body. If there is excess sugar or some other material in

the urine, it indicates that some other organs are not functioning properly. The doctors always ask for a blood or urine examination report so as to know what is wrong when you are sick.

### WASTE MATERIAL IN PLANTS

Plants have no special organs for waste removal like higher animals. But they have different methods. The gaseous wastes of respiration and photosynthesis ( $\text{CO}_2$ ,  $\text{O}_2$  and water) are released to the air. The stomata and the lenticels of the leaves and stems help in that. Some of the waste products of photosynthesis collect in the leaves and barks of the tree. The plants get rid of them by shedding of leaves and bark. Some wastes are stored as solid bodies. Rubber and raphides are examples of such bodies. Raphides are calcium oxalate crystals accumulated in some plant cells. These have needle shape and can be very uncomfortable when eaten. Sometimes when you eat yam (zamikand) your throat hurts. It is due to these raphides. Since they dissolve in acid, eating sour substances (such as tamarind) helps.

Some of the plant secretions are useful to us. Gums, resin, sandalwood oil and eucalyptus oil are such substances. Animal waste such as cowdung (*gobar*) is very useful as nutrient for plants and used as an organic fertilizer. It is also used as fuel in villages.

### ANSWER THESE

1. Is each statement true or false? If

false, correct the statement.

- (i) All organisms have some method of waste removal from their body.
  - (ii) Some organisms store wastes in body parts.
  - (iii) Blood carries both useful and waste materials.
  - (iv) Sweating does not help in waste removal from our body.
  - (v) Kidney acts as a filter to collect waste from blood.
2. What are the methods of waste removal in humans?
  3. Give examples of solid, liquid and gaseous waste in animals and plants.

#### 14.7 Reaction to Stimuli and Coordination

A multicellular organism has different parts for doing different jobs. But all these parts have to work in an ordered way for the organism to survive in changing environment. All the activities in life are inter-related. If there is no blood circulation we cannot get energy even if oxygen and food are taken in. Similarly, if digestion does not occur properly we cannot use the oxygen or perform cellular respiration. Can you guess what will happen if the kidney fails? The blood will be full of toxic wastes and all the cellular activities will stop. So all life processes are dependent on each other. They are also regulated in a systematic manner. We eat when we need energy. We breathe fast after exercise because the cells need more

energy. We also react to external changes in the environment in such a way that it is in order with the change. When the sun is bright we close our eyes. We try running away when we are scared. All these external stimuli yield response which involves many organs. But all the organs react in a systematic manner for the reaction to occur. This capability of doing the type of actions which are in proper order with the surrounding (external or internal) is known as *coordination*.

#### COORDINATION IN MULTICELLULAR ORGANISMS

*Reaction to stimuli* is a property of many living organisms. If you prick an earthworm with a needle, it withdraws. The sunflower always faces the sun. The method of reacting to stimuli is not similar in plants and animals. In fact, the animals can sense and react in diverse modes, whereas plants have limited reactions.

#### COORDINATION IN HUMANS

In many multicellular animals, such as humans, the reaction to stimuli and coordination of activities are performed by different organs and organ systems. In humans the nervous system and the endocrine (hormonal) system work together to control action, thinking and behaviour. The organs for the nervous system are brain, spinal cord, eyes, ears, tongue, nose and skin. We see, hear, smell, taste and touch and send this information to the brain. The brain has

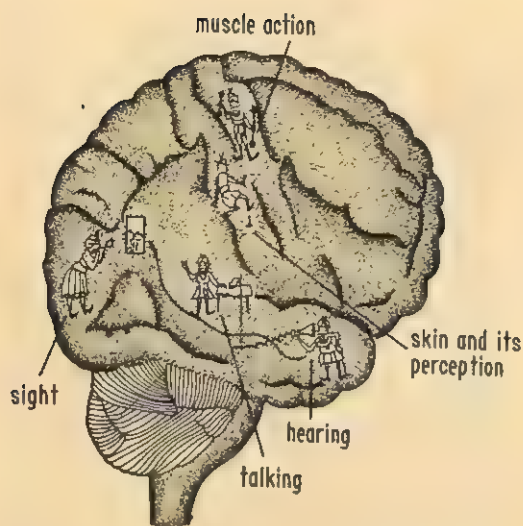


Fig. 14.12 *The Sense Centres and Various Regions of the Brain*

different regions for different senses (Fig. 14.12). Depending on what the stimulus is, the brain directs other organs their next job.

But how does the brain obtain information? Do you know how the conductor informs the bus driver to stop or start the bus? He rings a bell. So the sound of the bell acts as the messenger. In the nervous system this job is done by the nerve cells. Figure 14.13 shows the net of nerve connections from many parts of the body and the sense organs to the spinal cord and brain. There are different kinds of nerve cells (neurons) doing different jobs. Some receive and send messages to the brain and spinal cord. Some understand the message and decide on actions. Some carry action messages to muscles or glands. So when you see something frightening, your legs

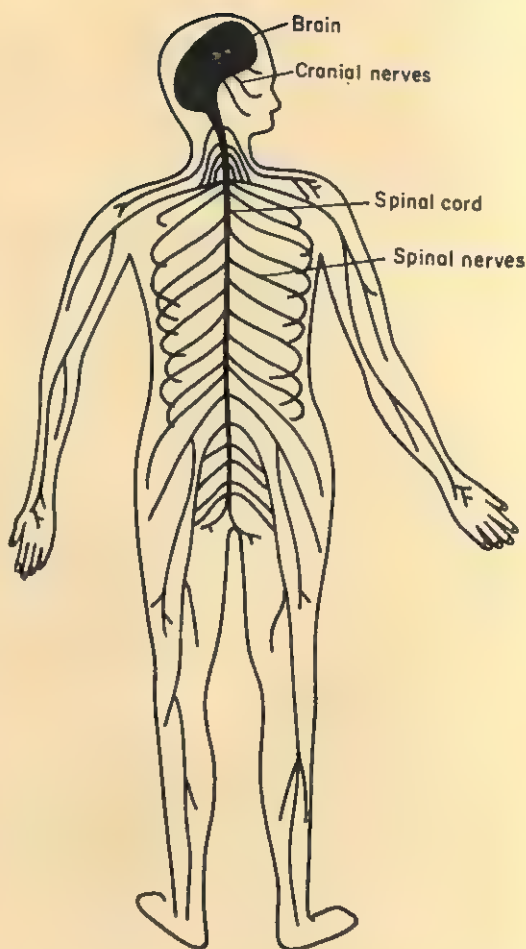


Fig. 14.13 *The Basic Network of Nerves. Not all the nerves are shown.*

get the message, *run*, from the brain.

The endocrine system also helps in coordinating our activities. There are some tissues (called glands) in our body which make and store chemicals called the *hormones*. These hormones affect different organs. They act as messengers between the organs and the nervous system. For example, when you are very

angry or exciting a hormone named *adrenalin* acts on the liver. The sugar level in the blood is increased by the liver. This increases the activity in the muscles and brain cells. So muscular responses and immediate thinking result. Figure 14.14 shows some of these glands in the body.

#### COORDINATION IN PLANTS

Plants do not have a nervous system but they coordinate their behaviour against the environmental changes by hormones. The hormones in plants do not act the same way as in animals. They coordinate by reacting with the tissue water or cell sap and affecting growth. The reaction

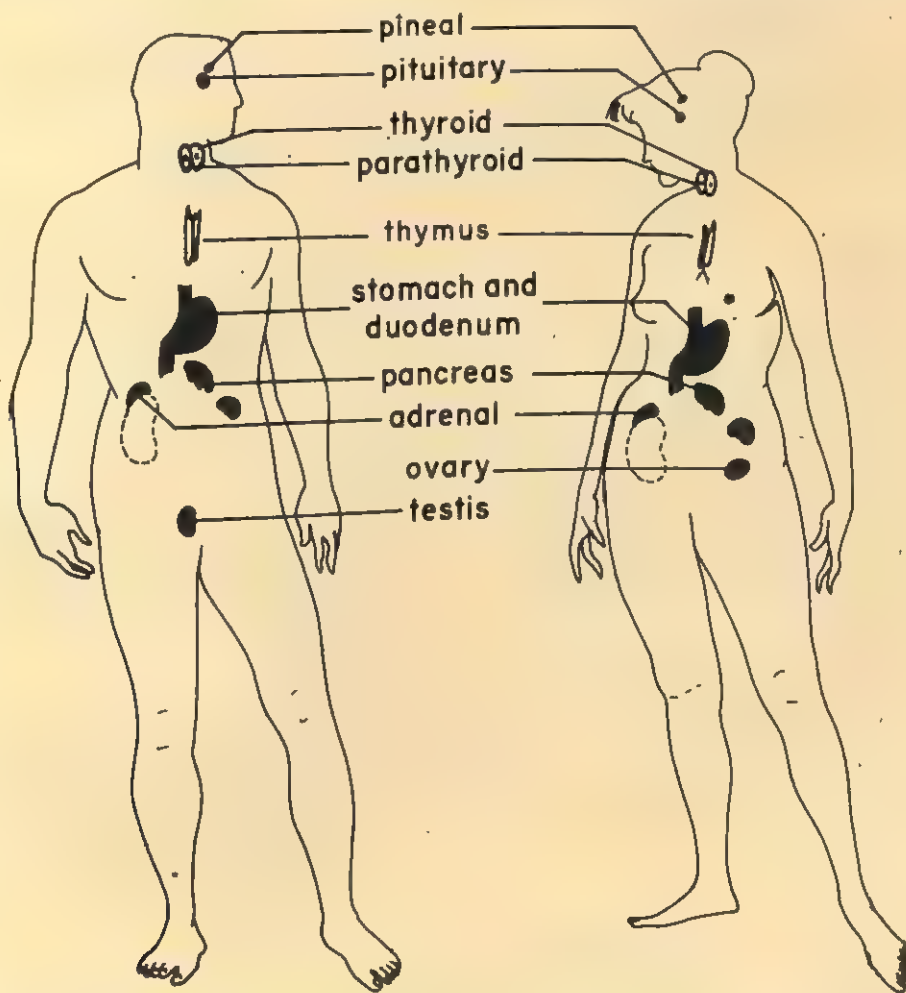


Fig. 14.14 The System of Glands, also called the Endocrine System in Men and in Women. Not all the glands are shown.

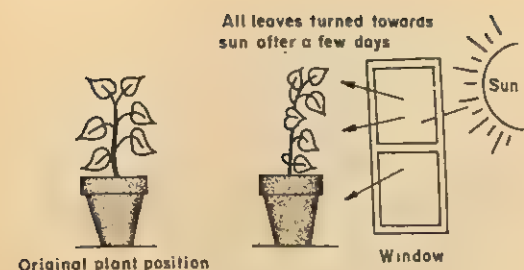


Fig. 14.15 Movement of a Plant towards Light, also called Phototropism

of plant cells to different stimuli such as light and water is due to these hormonal effects. The best known plant hormones are *auxins*. They are secreted by the meristematic tissue in the shoot.

#### Activity 8

Keep an upright shoot in a fairly dark room with light only on one side (say, right). After some days you will notice that the shoot tip has bent towards the right. Do you think that the plants are "aware" of the position of the light and grow towards it? What happens is the following: much of the auxin secreted on the right side of the shoot tip is destroyed by light, whereas the hormone persists on the left side. So the shoot-tip cells on the right do not grow as much as those on the left. So the tip bends over to the right (Fig. 14.15).

#### Activity 9

Take a small plant growing in a glass jar. Tilt it and keep the jar horizontally on its side. Observe the direction of growth of the roots and shoot. The root always goes down and the shoot goes up. This is

Leaves and stem grow upward and roots grow downwards

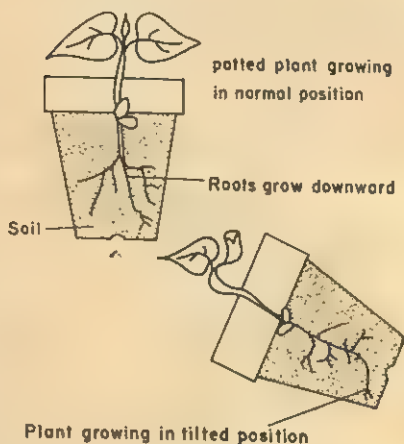


Fig. 14.16 Movement of Plant Root towards the Earth, also called Geotropism

called *geotropism* (movement towards or away from the earth) (see Fig. 14.16)

#### ANSWER THESE

- Match the related activities.
 

Exercise	Eating
Hunger	Urinating
Waste accumulation	Breathe fast
Bright light	Running away
Frightening object	Closing of eyes
- Name the two systems of coordination in humans?
- Do plants show reaction to external stimuli? What is the name of the main hormone involved?

#### 14.8 Locomotion (Movement)

The major difference between plants and animals is the ability to move.

Animals seem to be more alive to us because they can move around. The act or power of moving from place to place is known as *locomotion*. How does a train move? First it should have an engine. The engine should have energy to pull the train. The compartments should be connected properly and the driver in the engine should understand the signals. This means energy and coordination are very important. When an animal moves, it gets energy through nutrition and respiration. The decisions about the movement are made by the nervous system depending on the stimulus. This directs the muscular and skeletal system or the body to move. Just imagine how many organs of your body are involved when you move just a finger!

Other life processes also involve movement of some of the body parts. We move our teeth to chew and digest the food. Blood has to move from the lungs to cells for respiration. Heart beats to circulate the blood. When you run, it beats faster so that oxygen can reach the cells faster to produce more energy. Even the stomata in the leaf open and close to control moisture content. So movement of the whole body or its parts is important for all the life processes in most living organisms, especially the animals.

#### TYPES OF MOVEMENT

We use legs to walk from one place to another. The birds fly and the fish

swim. But all these animals use similar organs to do this. These are muscles and bones. Bones are hard tissues which hold or support soft tissues. Have you seen a

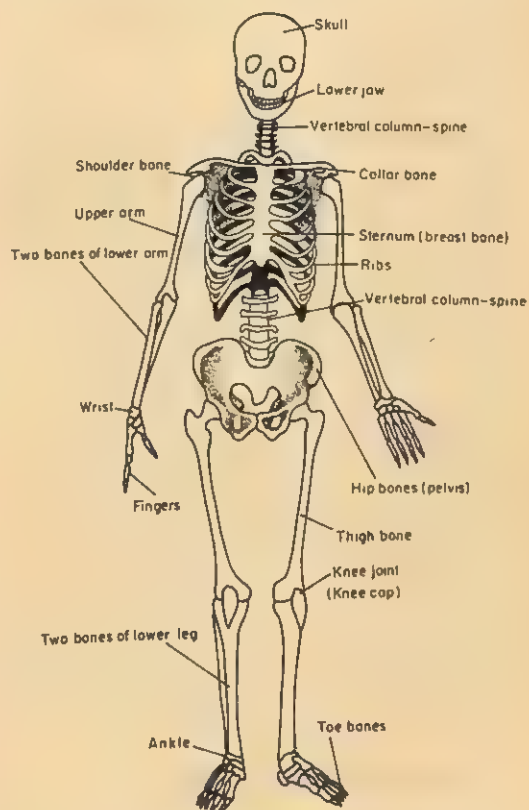


Fig. 14.17 The Human Skeleton. Only the major bones are shown.

clay idol being made? First a frame is made with wood and hay. Then clay is put onto it to make the body. It is the frame that holds the body. In animals, such as humans, the hard bones do this job. Here the frame is called the *skeleton*. Figure 14.17 shows the skeleton of a human being.

There are more than 200 bones in our skeleton. These bones are connected to each other through joints. This allows them to fold like a folding-chair. The muscle tissue helps in contracting or expanding. The birds use their chest muscles to pull and push or flap the wings to fly. Fish use their muscular tails and fins for swimming. Muscles and bones are both needed for movement in vertebrates. But earthworms and insects use only muscles for this purpose. The type of movement which includes both muscles and bones or muscles alone is known as *muscular motion*. It has variations, such as creeping, walking, swimming and flying. Snakes creep, fish swim, birds fly and we walk. Ostrich and penguin are birds but they do not fly, they walk. Ducks and swans can walk, fly and swim. We can learn to swim but cannot fly. Different kinds of structures are necessary for these types of motions such as wings, flat webbed-feet, tails, fins and limbs. They are all made of bones and muscles, but their structure gives them the ability to perform flying, swimming and walking.

There are three other kinds of animal motion: amoeboid, ciliary and flagellar. The amoeba extends pseudopods and then streams its jelly-like protoplasm towards that direction. This type of motion (amoeboid) is seen in many other organisms. Some organisms such as paramecium have fine hair called *cilia*. The euglena has a long tail called *flagellum*. Both help in moving in water or liquid environment.

### Activity 10

Collect some water from a pond. Take a drop on a slide and observe under the microscope. Note down the different types of movements you observe.

### Activity 11

Sit quietly on your seat and notice what all moves inside you. You will be surprised to note that even when you are "motionless", so many things are moving inside you.

### Activity 12

Collect some hydra from a pond and keep them in a shallow dish of water. Observe how they move. You will see the movements as shown in Figure 14.18. Notice that the hydra has to do a complicated set of movements in order to "walk".

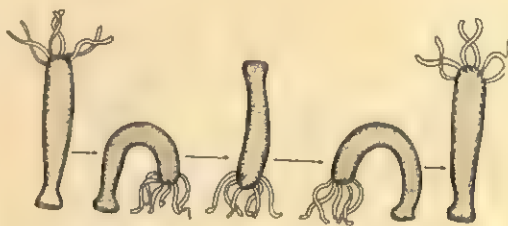


Fig. 14.18 The Steps of a Hydra "Walking"

### MOVEMENT IS CAUSED BY VARIOUS STIMULI

Organisms respond to different stimuli by moving toward or away from it. In phototropism in plants, the shoots move towards the source of light. We also know about the opening and closing of

guard cells of stomata to control water vapour level in the leaf. The leaves of the plant *Mimosa* droop if you touch them. This kind of movement is controlled by water absorption and loss by the plant cells. Some organisms move in response to external stimuli. This is known as *taxis*. When the stimulus is light or gravity, the movement due to it is known as *photo*-or *geotaxis*. You must have noticed that certain kinds of moths fly towards the source of light and eventually get burnt. In contrast cockroaches tend to avoid light. Bats also avoid movement during day time and go out to eat only at dusk.

Movement helps animals in adjusting to their environment. Since almost all animals are heterotrophs it is important that they are able to get their food from the environment. Movement helps them in searching for food. Movement also helps many other animal activities. When water sources dry up in one part of the forest, the animals can move (migrate) to the other parts. When it rains we all run for a shelter. Many organisms move to find a shelter or protection from changes in the climate. Have you seen the north-south migration of birds in winter? They all do that to avoid the cold winter.

### Activity 13

If you see a line of ants moving, wipe out a small portion of the line and then see what happens. Do they form the line again? Actually, while ants move they leave some chemicals behind. Other ants

### DO YOU KNOW HOW BEES INFORM OTHERS WHERE FOOD IS AVAILABLE?

The worker bee, after locating the food source, comes back to the beehive and performs a particular type of dance. People have found out that the movements during the dance convey the direction and place. If the source is near the hive, a "round dance" is performed. A "tail-wagging" dance says that the food source is more than 80 metres away. The distance is conveyed by the number of times this dance cycle is performed in a particular time. Slow dance means food is far away. The direction is also communicated through different movements in the dance. This variety of movements in the bee dance is an important method of communication in the bee society.

follow them by following the chemical trace. If you wipe out a portion of the line, they lose the chemical trail and disperse. They may form the line in a different way again.

### ANSWER THESE

#### 1. Match the following:

Digestion	Lungs
Respiration	Kidneys
Circulation	Stomata
Moisture control	Heart
Excretion	Stomach

2. What are the four kinds of animal movements?
3. What are the tissues involved in muscular movement?

### NOW YOU KNOW

- All organisms perform certain basic activities which are essential for life and its continuation.
- These processes are nutrition, respiration, excretion, response to stimuli, growth and reproduction. Energy is needed for all these processes.
- Green plants get energy by making their own food by photosynthesis. Other organisms depend on plants and each other for their food.
- There are specific organs for carrying on various steps of nutrition in multicellular animals.
- Respiration helps in getting energy by reacting oxygen with the digested food in cells.
- To transport solid, liquid and gaseous matter in different parts of the body, the circulatory system is needed.
- Plants use vascular tissue for transporting food, water and dissolved salts. Most animals, including man, do it through heart and blood circulation.
- All types of waste materials are excreted from the body. Animals have specific organs but plants do not.
- All the life processes are interdependent and coordinated.
- In animals coordination is through

the nervous and endocrinal systems. In plants it is only hormones.

- Movement of the whole or parts of the body are involved in all life processes of animals. Plants also show some kind of movement under different stimuli.
- There are four kinds of movements in the animal world. The most common form being muscular. Muscles and bones are organs for such movement.

### NOW ANSWER THESE

1. Name 5 herbivores and 5 carnivores.
2. What things in our mouth help in physical and chemical digestion?
3. What moves the food in the digestive organs?
4. What acts as a fuel for the working of a cell?
5. Name the organs of respiration in the following animals: fish, earth-worm and man.
6. State the functions of blood in our body.
7. What is a stoma? Give two functions of stomata.
8. Do all cells use oxygen to produce energy?
9. What is common between our nose, gills of fish and stomata of the leaves?
10. What are the major organs for respiration in humans?
11. What helps the amoeba to move from one place to another?

12. Name the organs of the circulatory system in humans.
13. Which tissue transports water in plants?
14. What is the main difference between an artery and a vein?
15. Name the two fluids which help in circulation in humans
16. What is blood transfusion?
17. What are the waste products formed in humans?
18. How do plants take care of their waste products? Name two waste products of plants which are useful to humans.
19. What is common between  $O_2$ , gum, sandalwood oil and raphides—in plants?
20. Which is our main excretory organ and how does it work?
21. Name the organs for nervous coordination.
22. Which are the tissues that help in sending information to all organs in humans?
23. Name two endocrine glands where hormones are made in humans.
24. What types of movement do the following animals show: fish, bird, amoeba, paramecium, snails, euglena, snake.
25. Give five examples from living organisms where movement of body parts are used for communication.
26. Match the items in the columns.

Breaking bulk food into smaller parts	Respiration
Running away on being scared	Excretion
Making energy in cells	Circulation
Sweating in summer	Digestion
Walking back to home	Co-ordination
Transporting digested food to cells	Locomotion

## Life Processes—II

ONE OF THE MOST important properties of living organisms is their ability to reproduce. All the life processes that we have studied till now help an individual to be alive. But all living things grow old and, in time, die. In order for a species of plant or animal to continue and survive, it must make more copies of itself. The production of new individuals from parents of the same species is known as *reproduction*. The process involves growth and development of cells, tissue and organs. In this chapter, you will learn some aspects of these two important life processes—reproduction and growth and development.

There are many ways by which new individuals are produced by their parents. Some hatch out of eggs like chicks and snakes. Some are born from their mother like kittens, puppies, and human-beings. Some grow out of the parent's body or its parts, such as hydra, yeast and onions. Some just split into two or more giving rise to more individuals, such as amoeba and many bacteria. But all these different patterns can be divided into two groups. These two methods of reproduction in plants and animals are: (i) asexual reproduction,

and (ii) sexual reproduction. In asexual reproduction the new individual comes from a single parent. Here one amoeba produces two daughter cells, one hydra is capable of growing many small hydras (buds). In sexual reproduction two parents are needed to produce new individuals or children. Most sexually reproducing organisms have special organs for this purpose. Specialised cells (reproductive cells or gametes) are made in these organs. Fish, frogs, humans and cucurbita flower all arise from two parents.

### 15.1 Asexual Reproduction

#### (A) BINARY FISSION

You have seen earlier in chapter 13 that an amoeba reproduces by simple division of its nucleus first and then splitting into two cells. Paramecium also divides like this. This method is known as *binary fission*. Figure 15.1 shows binary fission in amoeba and paramecium.

#### (B) BUDDING

This is another type of asexual reproduction observed in hydra and yeast. In hydra, first a small projection called a *bud* is formed in the side of the body

## LIFE PROCESSES—II

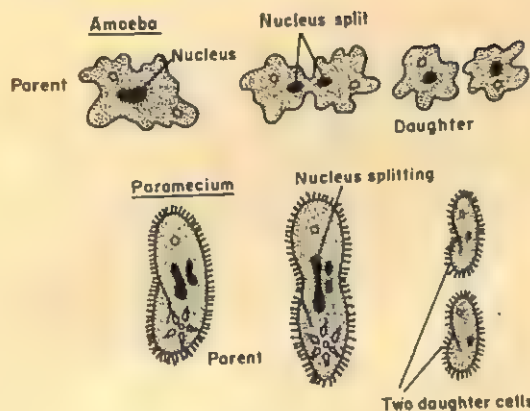


Fig. 15.1 *Binary Fission in the Amoeba and in Paramecium*

column (Fig. 15.2). This over a time of a day or two grows into a small hydra and then detaches itself from the parent body. In some organisms like sponges and corals, the buds remain attached to the parent organism. They then grow and produce their kinds. This is how a *colony* of sponges or corals is formed. Yeast also reproduces by budding. Figure 15.3 shows budding in yeasts.

### (C) SPORE FORMATION

Many fungi and bacteria, such as yeast and bread moulds, reproduce through

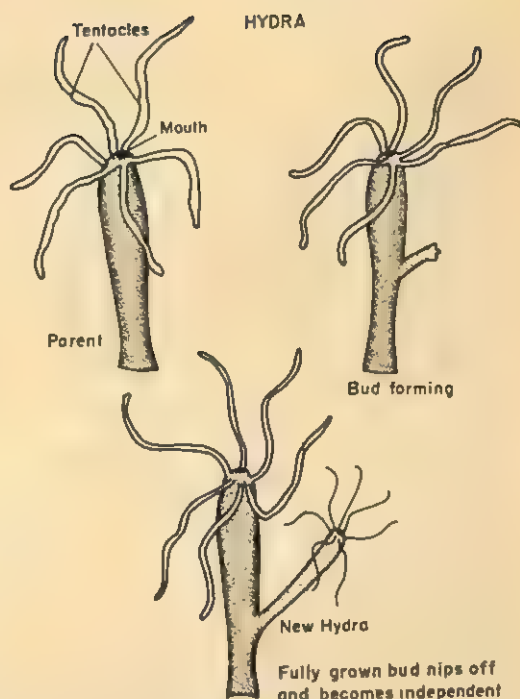
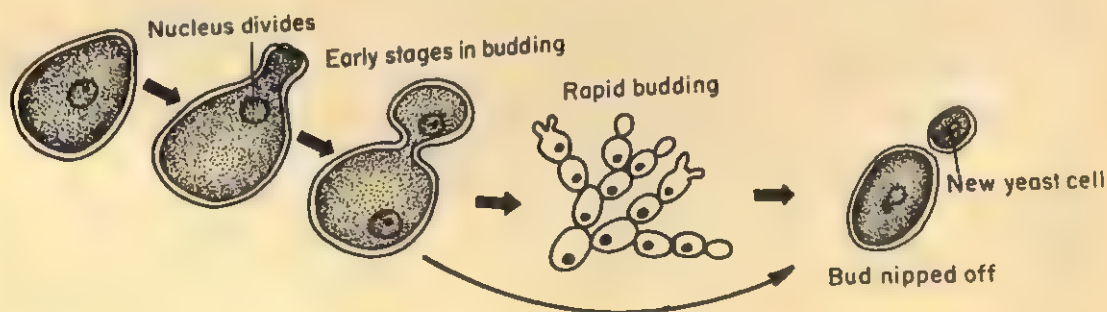


Fig. 15.2 *Bud-Formation and the Generation of a Daughter Hydra*

Fig. 15.3 *Bud Formation in Yeast Cells. Sometimes the bud nips off and grows as a separate new cell and at other times these cells remain attached and form a colony.*



**spore formation.** Spores are microscopic bodies covered by a hard protective coat. It enables them to survive extreme temperatures, lack of food and water. They can form new organisms when conditions are favourable.

#### (D) VEGETATIVE REPRODUCTION

Have you noticed how green grass springs up on the dry fields after the rains? Where does it come from? The dry old stems remaining on the ground give rise to the new plants. Tulip, lily or onion bulbs can also grow into full plants. Also some parts of potatoes, when planted, can give rise to new plants. In all these cases a new organism is produced from the body or a part of the parent. When new plants can be obtained from leaves, stems and roots without the help of any reproductive organs—it is called *vegetative reproduction*. You know that in plants only cells in the meristematic tissue can divide. These parts which give rise to new plants contain such tissues. Figure 15.4 shows some plants which reproduce this way.

#### (E) REGENERATION

Some organisms, such as hydra and earthworm, can make a whole organism from pieces of their tissues. A small tissue from the body column of the hydra makes a small hydra. This process of getting back the full organisms from body parts is known as *regeneration*. Figure 15.5 shows the process in a star fish.

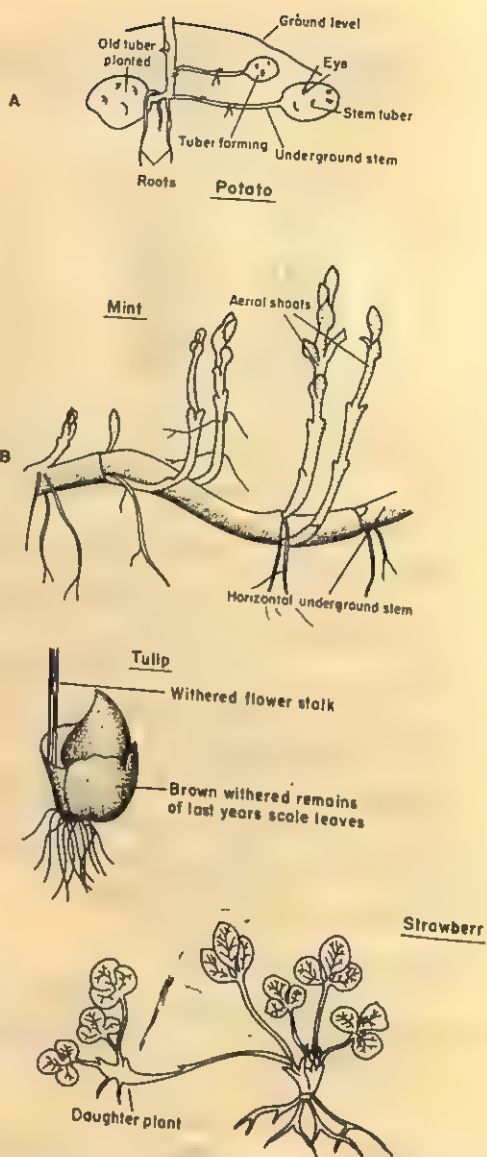
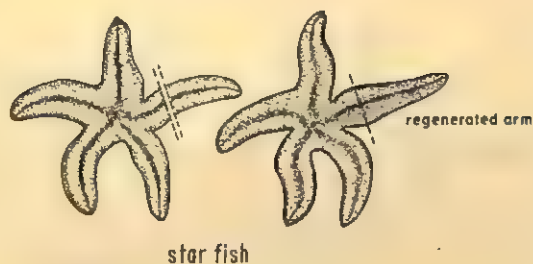


Fig. 15.4 Modes of Vegetative Reproduction from (a) Tubers of Potato; (b) Underground Stem of the Mint Plant; (c) Bulb of the Tulip and (d) Strawberry



**Fig. 15.5** *Regeneration of a Limb in Star Fish*

### Activity 1

Get a small piece of yeast cake (about 25 grams) from the bakery or any other shop. This will have at least  $10^8$  yeast cells in it. Break off a small piece and place it in a glass of warm water with a spoonful of sugar dissolved in it. Keep it in the warm part of the room. After an hour, put a drop on a glass slide, and observe under the microscope. You will see structures as shown in figure 15.3. You can also collect hydras from a pond and observe with a hand magnifying glass. You can see small buds attached to the parent body sometimes.

### Activity 2

Leave a piece of bread in air. The air should not be very dry. Then after two days observe the surface of the piece of bread with a magnifying glass. You will notice fine thread-like projections (*Hyphae*) and tiny blob-like structures on thin stems. These are bread moulds and the blobs contain spores. Keep a record of the number of blobs and how they develop. Take one blob on a slide and cover it with a coverslip. Observe under the microscope. You would see

spores. It is one of these spores which was airborne and grew on the bread.

### Activity 3

Cut a piece of potato on which there is an eye and plant it on a pot. Watch the roots, stems and leaves of a new potato plant growing. This vegetative method of producing potatoes is much faster than reproduction from seeds of the plants.

### Activity 4

Take a piece of stem from the 9 O'clock plant or *Bryophyllum*. Plant it in a pot or in the garden. You will get growing plants in a week's time. Branches of 9 O'clock plant with flower buds resume flowering soon.

### ANSWER THESE

- Match the following:  

Amoeba	Budding
Bread mould	Regeneration
Yeast	Spore formation
Potato	Binary fission
Lizard	Vegetative propagation
- What is the basic difference between sexual and asexual reproduction?
- Name two organisms which reproduce by two types of asexual methods. What are the methods?

## 15.2 Sexual Reproduction

This is the most common method of reproduction in plants and animals (both single-celled and multicellular). In

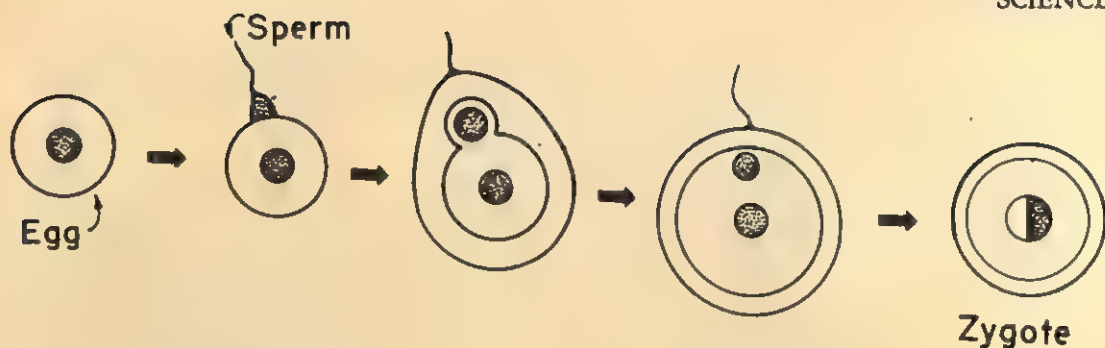


Fig. 15.6 (a) Fertilisation of an Egg by a Sperm Cell and the Formation of a Zygote

this process two reproductive cells (gametes) arising from the reproductive organs fuse to form a third cell called the *zygote*. This process of fusion is known as *fertilisation*. In higher plants and animals these two gametes are known as sperm and the ovum. The sperm is a small cell with a flagellum for movement. Ovum is a larger cell with more cytoplasm. During fertilisation the sperm fuses into the ovum and forms the *zygote*. Figure 15.6 (a) shows this process. The *zygote* then goes through specific changes and forms the new individual. There are various ways this can happen. In complex multicellular organisms there are special organs to both produce these gametes and also allow fusion of these cells.

In a large number of organisms individuals carry only one kind of gamete, either sperm or ovum. Frogs, fishes, birds, reptiles and humans are such animals. Depending on the type of gamete they carry they are called males or females. Females carry eggs. They have special organs called *ovaries* to make egg cells. Males carry sperm cells

and they are made in the organ *testis*. In flowers these are called *pistil* and *stamen*.

There are some organisms where both the gametes exist in the same individual. These organisms are called *hermaphrodites*. Earthworms and leeches and flowers in most of the plants are such organisms. In these flowering plants the flower is the reproductive organ. All the beautiful colours and scents of flowers are not for us, but to attract insects. They, while collecting the nectar, also help in pollination. This leads to fertilisation of the two cells.

The process of these cells coming together for fusion varies in nature. In humans, cats, dogs and birds fertilization occurs inside the female body. But in frogs and most fishes both eggs and sperms are released to each other in water where fertilisation occurs by collision. You know that in plants wind, water or insects help in pollination.

After fertilisation how the *zygote* will grow to a full organism also varies a lot. A chick comes out of an egg. Here the mother lays the egg and then keeps it



Fig. 15.6 (b) Male and female reproductive system in humans

warm. Cats and dogs give birth to young ones. In this case the organism grows inside the mother. The same process is seen in humans.

Humans have many organs in their reproductive system. Look at Figure 15.6b. In man, there is a pair of testes (gonads) in the scrotal sac located outside the abdominal cavity. Attached to each testis, there is the epididymis which stores the sperms. This is continued in the form of vas deferens, a tube that carries sperms. There are many other organs which help in maintenance of sperms. Each contributes to the formation of semen. In women, there is a pair of ovaries. The ovaries are followed by oviducts. The oviducts end into a common single uterus. The female germ cell, ova, is discharged from the ovary

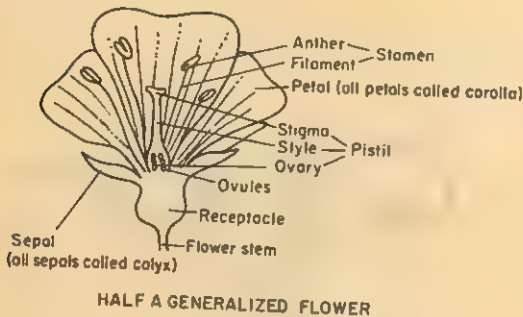
and gets fertilised in the oviduct. The development of the embryo takes place in the uterus. The embryo develops into a full baby before it comes out from the mother's body.

In the flower, the fertilised egg develops into the seed. The ovary containing the seeds develops into the fruit. New plants grow out of the seeds under suitable conditions of water, light and heat. This is how the species continue.

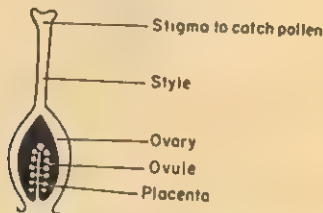
### Activity 5

Take a large flower (say, a petunia). Cut one side of the petals up to the stalk (as shown in figure 15.7 for a general flower). Note down all the parts as you see in the flower and compare with the figure. Observe a similar flower in the

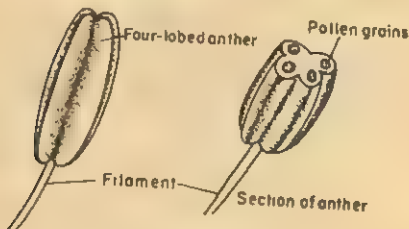
plant and note down the changes as it withers. What is left when the petals dry up?



HALF A GENERALIZED FLOWER



PISTIL—FEMALE REPRODUCTIVE ORGAN



STAMEN—MALE REPRODUCTIVE ORGAN

**Fig. 15.7** *The Reproductive Organs of a Flower. The pistil contains the ovary and the stamen contains the anther. Pollen grains from the anther fertilise the ovules in the pistil. Pollination is done by birds, bees, insects and butterflies at the stigma of the pistil.*

### ANSWER THESE

1. Fill in the blanks

(i) The cells involved in sexual

reproduction are called \_\_\_\_\_

(ii) Fusion of the gametes gives rise to a single cell called \_\_\_\_\_

(iii) The process of fusion of gametes is called \_\_\_\_\_ in animals and plants.

(iv) Animals having both reproductive organs are called \_\_\_\_\_

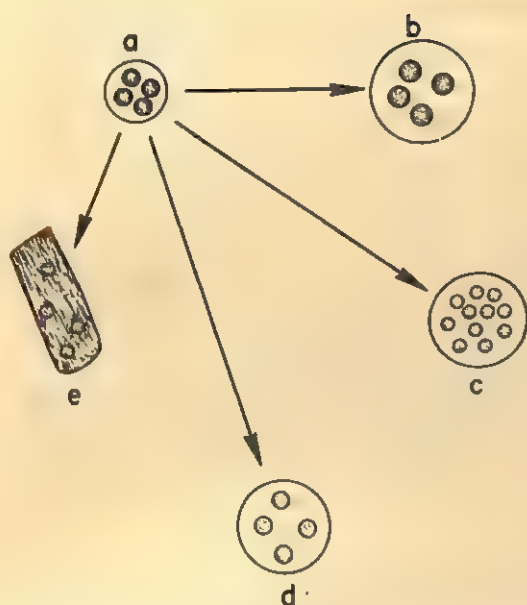
2. How do insects help in cross-pollination?

3. What are the organs in humans which produce the gametes?

### 15.3 Growth and Development

All living organisms start from either body parts or a zygote through asexual and sexual reproduction. The formation of an adult organism from young ones or zygote involves making many parts of the right pattern and right size. The process of forming specific shapes and patterns and increasing in size is known as *development and growth*.

We know that the babies grow up, plants grow from seedlings, lizard grows its tail back when cut. Here you notice that growth means getting bigger in size. But they **do grow** in such a way that the original pattern remains the same. The mango trees always look the same and do not look like a papaya tree. The lizard's tail grows the same shape and size as the original tail was. So growth involves changes in size and shape both. This can be understood easily from Figure 15.8: (a) is a rubber bag with four marbles in it. There are four ways (a) can grow—(b) by having larger size marbles; (c) by



**Fig. 15.8** *Four Different Ways of Growth with Increasing Size and Shape*

increasing the number of marbles of the same size; (d) by inflating the bag and (e) by adding large pieces of wood or packing material which increases its size and changes the shape.

The growth of parts in a multicellular organism follows the same principle. Here cells in each tissue increase in number by division and change in size and shape. The size of the tissue can also increase by other deposits (packing material). These ways of cellular growth lead to increase in size of tissues and organs of the body. So the whole organism shows overall growth. An amoeba grows almost double its size by feeding just before it divides. This increase in volume is due to increased

synthesis of its cellular constituents and increase in its water content, which increases the space between the parts.

Most animals grow upto a certain age and then stop growing. This means that they do not grow in size any more. It is possible to have cell divisions in such organisms to maintain their body. Everyday many cells of our skin slough off and new cells take their place. Some animals can even regenerate body parts. A lizard grows its tail to the same size by cell multiplication. Humans stop growing after about 20 to 25 years of age. Beyond that age no new tissue growth takes place. Growing fat cannot really be called growth. It is due to layers of fat deposited under the skin rather than new cell division or growth. Growing nails is also not growth but accumulation of dead skin cells at the bottom of the nails.

Plants grow throughout their life. They grow fast in early stages and later only in parts. Active cell division at the root and shoot tips increases the size of the plant at early stages. The stem or trunk of a woody tree grows in diameter. This growth is due to the continuous activity of the meristematic tissue in the trunk (cambium layer) and also due to changes in the shapes of the cells of the vascular tissues.

#### DEVELOPMENT IN MULTICELLULAR ORGANISMS

Multicellular animals start their life from a single cell—a seed, a spore or a

### HOW DO YOU KNOW THE AGE OF A TREE?

We know that in the stems new vascular tissue is obtained from the activity of the cambium. In summer, when soil moisture is low, the new xylem cells which carry water are small. After the rains the water-conducting cells grow large by expansion. The alternate narrow and wide xylem tissues can be seen as concentric dark and light bands if a tree trunk is cut horizontally (Fig. 15.9). These bands are called *annual rings*. Since only one ring is formed in one year, just by counting the number of these rings you can know the age of the tree.

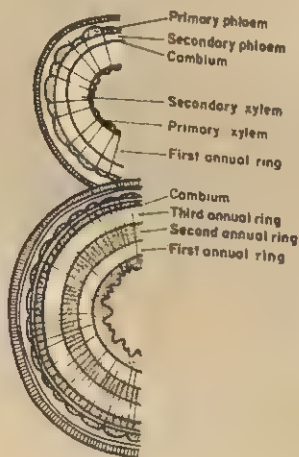


Fig. 15.9

Trunk of a Tree showing the Annual Rings

fertilised egg. The formation of a fully formed multicellular individual from this basic cell involves many steps. The seed and spore germinate and the zygote forms an embryo. All these terms mean that the growth starts in these basic cells. This is the first step towards formation of a plant or an animal with a form. This process of formation of the individual from some basic unit (such as a seed, zygote or a body part) is known as *development*. The process of development includes growth by cell division, change in cell shapes and cell movement.

After fertilisation, cell division takes place and the single cell zygote becomes a mass of cells. Next, cell movement takes place and different layers of cells are formed. Very ordered changes take place in this ball of cells and the cells become different in size, shape and function to form different body parts. Once the parts assume the right forms, the small individual is born or hatched out of the egg. Then onwards it grows to an adult form.

There are a variety of ways in which the individual organism develops. You know that many insects, such as butterfly and mosquito, have different stages of development between hatching of the eggs and formation of the butterfly or mosquito. They go through a worm-like stage called the *larva* and an encased form called the *pupa*. Figure 15.10 shows some examples of this form of development in butterfly and mosquito. Some-

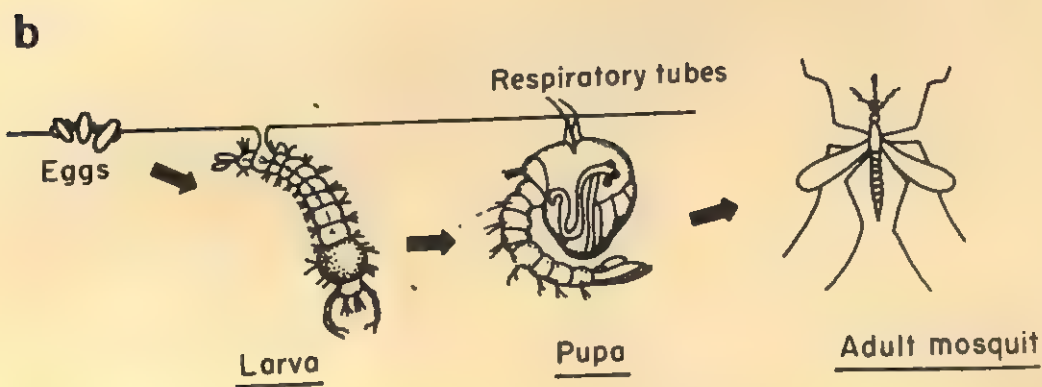
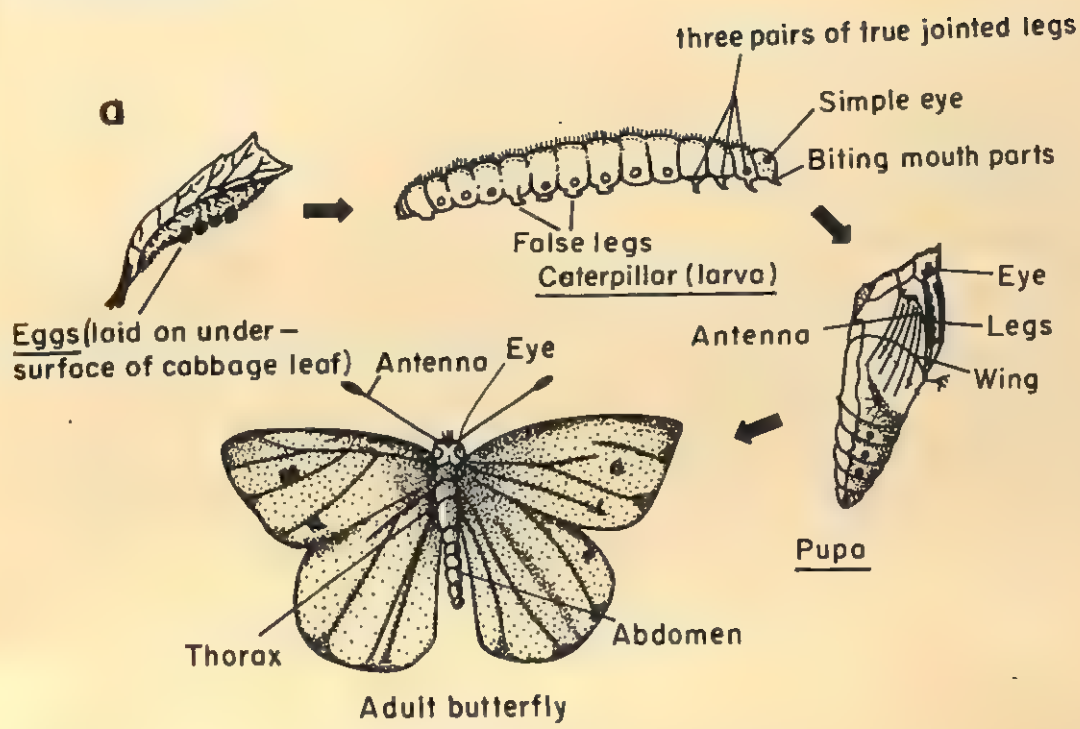


Fig. 15.10 Stages of Growth from the Egg to the Larva and Pupa to the Adult Stage in Butterflies and in Mosquitoes

times at home you can see some insects in rice, flour and other grains. If you look carefully you can identify the different stages of development of these insects, *larvae* and *pupae* and adults.

An adult human being has as many as 600 trillion cells in the body. All this has come from one cell through the process of growth and development. The organs are made in the right place and have the right size. The nerve connections are of the right kind so that we can coordinate our actions in the right way. Is it not amazing how all this happens? Some of the details are known but scientists are still working hard to find out the actual process of how it happens.

#### Activity 6

Plant a maize seed and Bengal gram. Observe and note down the number of leaves that come out.

#### Activity 7

Take the height and weight of ten students from every class in your school. Take the same of your teachers. Repeat the same after six months. You will notice that children grow faster than adults.

#### Activity 8

Measure the length of the head and the whole body of a small baby (say 6 months—1 year old). You will see that the head is quite large compared to its body. Repeat the same for an adult. You will notice that the head is much smaller

compared to the whole body. It shows that the head stops growing in size after certain age, but other parts grow for a little longer.

#### Activity 9

Collect a caterpillar from any tree and keep it in a glass jar with some leaves of that tree. The leaves are its food. Keep some holes for air passage on the cover. Then observe its development to a butterfly. Note down the time it takes to change from larva to pupa to adult and how it changes its body.

#### ANSWER THESE

- Are the following statements true? If not, why?
  - A tissue can grow in size only by increasing the number of cells in it.
  - An amoeba grows on feeding because it not only increases its organelles but also the cytoplasm.
  - Growth involves changes in shape, size and number.
  - The process of development in human and butterfly is the same because they both start from a zygote.
- Give some examples of growth in plants and animals.
- What are the stages in development of a butterfly from its zygote?

#### YOU NOW KNOW

— Living organisms produce more of

- their kinds to continue on the earth.
- There are two methods of reproduction: (i) asexual and (ii) sexual.
  - Asexual methods included binary fission, bud formation, spore formation, regeneration and vegetative reproduction. These involve only one parent.
  - Sexual method involves male and female gametes. Fusion of these two gametes is called fertilisation.
  - In multicellular organisms sexual reproduction occurs by the participation of organs which are different in females and males.
  - Growth of parts involves changes in size, shape and number of constituents.
  - In a unicellular organism, the cell size increases with growth.
  - Plants can have indefinite growth but animals do not.
  - Development involves the formation of an individual from the zygote, spore or seed.
  - Some organisms, such as the butterfly, go through larval and pupal stages during development.

### NOW ANSWER THESE

#### 1. Fill in the blanks:

- (i) The process of \_\_\_\_\_ ensures continuity of life on earth.
- (ii) The male and female gametes in the flower are called \_\_\_\_\_ and \_\_\_\_\_.
- (iii) Animals that produce only one kind of gamete in them are

known as \_\_\_\_\_

- (iv) In \_\_\_\_\_ reproduction one individual can make many new individuals from its body parts.
- (v) \_\_\_\_\_ grow throughout life, but \_\_\_\_\_ grow only upto certain age.
- (vi) A multicellular animal starts its life from a \_\_\_\_\_ through sexual reproduction.
- (vii) During development the butterfly passes through the \_\_\_\_\_ and \_\_\_\_\_ stages.

#### 2. Match the items in the columns:

Caterpillar	Growth
Sperm	Female organ
Leech	Larva
Ovary	Male gamete
Cell	
multiplication Hermaphrodite.	

3. How does an amoeba reproduce?
4. Where do the moulds on bread come from?
5. Explain the terms: Binary fission, regeneration, fertilisation and hermaphrodite.
6. What are the reproductive organs in a flower? How does pollination occur? What is a seed?
7. Give some examples of different modes of fertilization in nature. Do all organisms give birth to individuals like humans?
8. What are the stages of development butterfly and mosquito eggs go

through?

9. How many ways can a tissue grow in size?
10. What are the different ways in which reproduction in plants can occur?
11. Growth and development involves cell multiplication, cell movement and cell specialisation. Explain.
12. What are gametes? What is the difference between a unisexual and a hermaphrodite?
13. Write down the different methods of asexual reproduction. How is a colony formed?

## CHAPTER SIXTEEN

### Food

WE KNOW that for any machine or an engine to do work, it needs energy. The steam engine uses the energy of steam to run. The diesel train engine uses energy from burning diesel oil. Electric trains use electricity to run. And when petrol runs out, a car will not move. Living things are similar to these. As long as

you eat food, you can do work, grow and live. It is from food that you get energy. This energy lets the body maintain itself, do work and grow. Food is the fuel for living things as petrol is for a car. A car engine burns the fuel petrol and converts the energy obtained for moving. We burn the food that we eat and use the

TABLE 16.1

Differences Between Machines and Living Beings

<i>Machines</i>	<i>Living beings</i>
Only one kind of fuel can be used by a given machine—petrol, diesel, or electricity.	Different kinds of food can be used as fuel by plants, animals and microbes.
One kind of fuel is enough to run the machine.	Different kinds of food are necessary for proper health. Just one kind alone is not enough.
Parts of a machine wear out with use. Giving more fuel will not produce new parts to replace the old. Also, the machine does not grow in size	Eating proper food helps the body grow and maintain itself. Many worn out parts get replaced upon eating food—cells, nails, hair, blood. Living beings try and repair some of their parts and they grow in size.
These can only do <i>downhill</i> work. That is, many machines burn the fuel by chemical reaction. Fuel is rich in energy and the waste products poor in energy.	Can do both downhill and uphill work. That is, they can also store extra energy for future use.
Many fuel engines burn the fuel at high temperatures to get energy.	Living machines burn their food (fuel) at low temperatures.

energy to build our body, maintain its health and work. The body is thus a living machine.

### 16.1 The Body is Different from the Usual Machines

There are many differences between living and ordinary machines. Some of these are listed in Table 16.1.

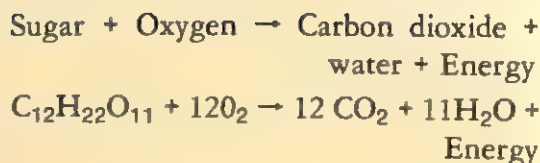
#### ANSWER THESE

1. We have listed only a few differences in the Table. Can you think of any more? Prepare your own table for these.
2. Make a list of different living organisms in your locality. Write down the main food that they eat.
3. List the various types of fuel used by different machines and engines.
4. Is there a machine or engine that uses sound as the source of energy? Or one with magnetism as the source? Or just sunlight alone?

### 16.2 Food has Many Components

#### CARBOHYDRATES

Food is essential for us to do work, to grow and maintain life and to keep healthy. Food has many different constituents, each necessary for some function or the other. We eat and burn it as fuel from many types of food material. Yet the substance that is used as the chief energy food is *carbohydrates*. One simple form of carbohydrates is sugar. When sugar is burned in air, it produces heat and light as energy.



The energy contained in the molecules of sugar is released upon burning in oxygen. The products of the reaction, carbon dioxide and water, have less energy in them. When we eat sugar, our bodies use it to release energy. The body does not burn it at high temperatures. Nor does it do so in one step. Instead, it breaks the molecule in several steps, each releasing some energy. The breaking down is done at 37°C, helped by molecules called *enzymes*. Very little heat energy is released as waste. The energy from the sugar is stored in chemical form for use by the body.

Of course, we eat only a little bit of sugar everyday. The main carbohydrate that we eat comes from rice, wheat and cereals and is called starch. Starch is made by putting together many molecules of sugar chemically, and is hence called a *polymer* (the term 'poly' means 'many' and 'mer' means 'units'). Its energy content is thus far larger than that of a sugar molecule. The energy in food is measured in *calories*, which, as we saw in chapters 4 and 5, are units of heat. The Calorie mentioned here is actually a kilocalorie or 1000 calories. (The modern unit for heat is *Joule*, but food scientists are still using the Calorie). Table 16.2 shows how many Calories people need everyday for their activities.

TABLE 16.2  
Average Daily Calorie Needs

Person	Calories per day
a 10-12 year old child	2000
a 12-14 year old girl	2200
a 14-16 year old boy	2600
a 15-18 year old girl	2600
a 15-18 year old boy	3000
a man doing hard work	2500-4000

The main food that we eat to provide us with energy is called *staple* food. Rice, chapati and bread are some examples. This is why we use them as the main dish in our meals. Table 16.3 shows the Calorie content of the food we eat.

TABLE 16.3

Some Foods and Their Calorie Values of Energy

Food	Portion	Calories a portion
Chapati	One	150
Bread	1 slice	70
Apple	1 large piece	100
Rice (cooked)	100 grams	500-600
Butter	1 tablespoon	100
Milk	1 cup	150
Meat, lean	50 grams	100
Egg	1 large size	100

### Activity 1: Test for Carbohydrates

Potato and rice contain high amounts of the carbohydrate starch. Start with a

piece of boiled potato and some cooked rice. In a glass vessel (beaker, drinking glass or similar colourless vessel), put in the crushed boiled potato, add water and stir well. In another such vessel, crush a pinch of the rice, add water and stir well. In a third vessel, simply add water alone. To each of the three vessels, add two drops of *iodine* solution. Starch will give a blue colour with iodine. Water will not. In fact, the iodine test works even if you use a raw cut potato.

### FATS

Table 16.3 shows that a little butter has more calories of energy than a slice of bread. Butter is an example of another type of food material called *fats*. Fats contain less oxygen in them than carbohydrates do. So, when they are oxidised, they produce more energy. Our body converts the food it eats into energy and stores part of this energy as fats. Fats are thus like an energy bank in living organisms. Many animals like the bear, the whale or walrus store energy in their bodies as fat for future use.

Fats are important not only as stored energy but also for the flavour and taste that they give to the food we eat. Oils like the ones used in cooking, butter and ghee, milk and cheese and nuts like groundnut and cashew are rich in fats. All oils and fats have a greasy feel about them just as starch has a sticky feel about it.

### POLAR BEAR

The polar bear in Canada, USSR and other places near the Arctic Continent is famous for storing fat in its body. The winter is severe there for many months of the year. During this time, the polar bear *hibernates*, that is, it simply sleeps for months on, to wake up only when springtime arrives. During this long sleep, it seldom eats. All the energy its body needs for living in the harsh winter comes from the fat it has stored in its body before winter. It eats enormously before winter and stores the energy as fat during hibernation! A polar bear is fat and chubby before winter. After it wakes up in spring, it is leaner since much of its stored fat is used up. We humans do not hibernate and store fat as much as the polar bear does. But we still do it to some extent. Fat people have more fat stored in their bodies than thin people.

### Activity 2: Test for Fats

Here is a very simple test for fats. Put a drop of oil or butter on a piece of white paper. On another piece of white paper put a drop of water. Let the papers dry and hold them up to the light. What difference do you see between the two papers? The paper with the fat is translucent at the spot. The paper that

had the water is not! You can do this test with ghee, cooking oil or coconut oil.

### PROTEINS

We had said that the body breaks down, or digests, carbohydrates with the help of enzyme molecules. Enzymes belong to a class of substances called *proteins*. Proteins are also polymers, but made of amino acids. They contain nitrogen besides carbon, hydrogen and oxygen. Some proteins contain other elements like sulphur, phosphorus and some metals as well. Some proteins help in digestion and in building body materials. Some others act as the body materials themselves. Muscle is mainly made of proteins. Skin, hair and nails are also proteins. The wool of sheep, lamb, bear and other animals is a protein as also silk from silkworms. Cotton and paper, on the other hand, are carbohydrates. Blood contains a protein called haemoglobin that carries the oxygen that we breathe from the air to our body cells. This oxygen is used in oxidising the food molecules producing carbon dioxide. Haemoglobin also carries the waste carbon dioxide to the lungs from where it is breathed out. Other proteins help in repairing damaged parts, replacing worn out or dead cells and tissues. Meat, fish, eggs, milk and all pulses (*dal*) are rich in proteins.

### TEACHER DEMONSTRATION

#### Test for Proteins

*Material:* Hard glass test tubes or boiling

tubes, beakers, concentrated nitric acid, ammonium hydroxide, spirit lamp or kerosene stove, one hard-boiled egg white.

*Procedure:* Put a small piece of the egg-white in the test tube and add a few drops of the acid and heat. Do not boil. Note that the colour of the egg white has become yellow now. Decant the acid into a beaker of water to dilute and discard it, but keep the egg white in the tube. Now add a few drops of ammonium hydroxide to the egg white and note the colour. It has now turned violet.

#### VITAMINS AND MINERALS

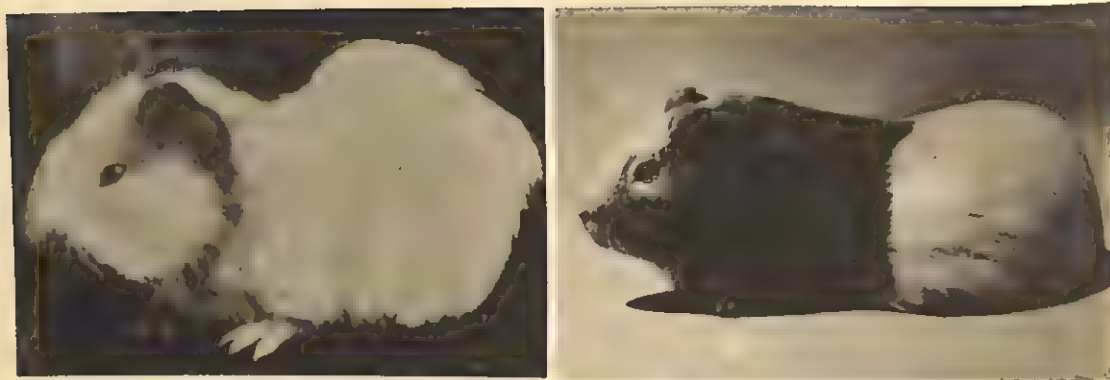
The class of molecules called *vitamins* are also helping materials. Some vitamins and related molecules often help enzymes do their jobs, and hence called co-enzymes. Some vitamins help in keeping our eyes, teeth and gums, and bones healthy.

*Minerals* help in the formation of blood, bones and teeth. They usually contain elements like phosphorus, sulphur, nitrogen, chlorine, iodine and metals like sodium, potassium, calcium, magnesium, iron, zinc, cobalt and others. Several minerals are also needed for many enzymes to do their work. Unlike carbohydrates and proteins, the amount of vitamins and minerals needed in our diet everyday is not large. But we must have them in the diet since the body does not make these. Without them, it will be like the story—*For want of a nail the kingdom was lost!* Fruits, vegetables,

milk, meat, fish liver oil and hard polished rice are some foods that contain these essential substances. Figure 16.1 shows two rats. The one at the top had been eating food that did not have the vitamin called Vitamin A. The other one had a proper diet. The rat at the top had badly formed eyes and an unhealthy skin.

Fig. 16.1 *The rat at the top was fed a diet lacking in vitamin A. The other had a properly balanced diet. Note the eyes and the fur in both cases.*





**Fig. 16.2** *The guinea pig shown on the left has scurvy. Addition of vitamin C to its diet restored its health to normalcy as seen on the right.*

The other rat is healthy. Carrots, butter and spinach are good sources of Vitamin A. Figure 16.2 shows a guinea pig that has the disease called scurvy. The animal fell sick because its diet did not have enough Vitamin C. When this vitamin was added to its diet, it became a normal, healthy and attractive guinea pig. Vitamin C helps in proper growth, healthy teeth, gums and joints and helps the body fight diseases and infection. Fortunately Vitamin C is found in all fresh fruits and vegetables. Tomatoes, lemons, oranges and gooseberries (*Amla*) are rich in this important vitamin.

### *Activity 3: Test for Vitamin C*

Remember the iodine test for carbohydrates? You can do a similar one here. Do the iodine test first, using carbohydrate and iodine, as described in Activity 1. Let the blue colour form. Now cut a lime or a lemon and squeeze the juice into a beaker or similar vessel. Take

the juice in a dropper. Add the juice drop by drop into the blue coloured starch-iodine solution. Note that the blue colour disappears and a light brown colour forms. This is an excellent test for the presence of Vitamin C. You can try this with other fruit juices also. Besides A and C, there are several other vitamins that our body needs. We shall learn more about them in the next chapter.

### WATER

Water is the essence of life! It is needed in the digestion of food, to get rid of waste material, and for many other purposes. Most of the reactions in the body occur in water solutions. In fact, 60-70% of the body weight is simply because of the water it has! A 12 year old boy who weighs 35 kg has about 25 kg of water in him! This is also true of vegetables, fruits, animals and plants. A good example is the fruit—grape. More than 80% of its weight is water. A dried

grape is what we know as raisin or *kishmish*.

#### Activity 4: Water Content in Food Material

(i) Take one grape and many (about 20 may do) raisins. Using a balance, find out how many raisins are needed to balance the weight of one grape. You do not need an accurate balance or weights. You can even make your own balance using a plastic drinking straw or a long pencil, some pins, thread and paper. See how many raisins are needed to balance the weight of the grape.

(ii) Now, soak the raisins in water for 30 minutes. Take the swollen raisins out and carefully wipe the water from their outside. You can use a dry handkerchief, thin towel or cloth, or blotting paper. Do not break up or squash the raisins. Now you have water-filled raisins. Using the balance again, see how many of these raisins equal the same grape in weight.

(iii) Next, take three of the soaked swollen raisins in the left pan and find out how many dry raisins are needed to balance the weight. Prepare a Table of results as below.

You have the weight of 1 grape in terms of dry raisins from item (i) and the same in terms of swollen raisins from item (ii). Can you calculate from these how many dry raisins equal one swollen raisin in weight? Does your calculation agree with what you found out in item (iii)? If not, do the experiments again. If yes, you have finished the activity successfully. Now you can eat up the grapes and all the raisins! or may be you should wait until the next activity is over.

#### Activity 5

You can do a similar experiment with sliced potato pieces. In making potato wafers, potatoes are sliced into thin wafers and dried in the sun. The fresh potato slice is not brittle, it is pasty and you can feel the starch. The dried piece is brittle and breaks with a mild sound. This change is just because all the water is evaporated upon drying in the sun. You can use the balance to find out how much weight the fresh potato slice loses upon drying. You can use dry raisins again as the weights.

(i) Weight of four fresh potato slices = \_\_\_\_\_ raisins

Relative Weights of Grapes and Raisins

Left pan	Right pan	Weight of
(i) 1 grape	_____ dry raisins	1 grape = _____ dry raisins
(ii) 1 grape	_____ swollen raisins	1 grape = _____ swollen raisins
(iii) 3 swollen raisins	_____ dry raisins	1 swollen raisin = _____ dry raisins

- (ii) Weight of one fresh slice = \_\_\_\_\_ raisins
- (iii) Weight of the four slices after drying = \_\_\_\_\_ raisins
- (iv) Weight of one slice after drying = \_\_\_\_\_ raisins
- (v) Percentage weight loss upon drying = \_\_\_\_\_
2. Which substance offers more energy gram for gram: Fat or Carbohydrate?
3. What are the various functions of proteins?
4. What is the main difference between vitamins and minerals?

The value you get in (v) is the percentage of water in the fresh potato. Now you can eat the grape and the raisins. The potato is better thrown out than eaten!

#### ANSWER THESE

1. What is a Calorie? How is it related to the calorie that we read in chapter 4?

#### 16.3 Diet that You eat should be Balanced

We have seen that the food that we eat should have carbohydrates, proteins, fat, vitamins, minerals and water. Each component is important as shown in Table 16.4, but how much of each should we have? In other words, what is the best balance in our diet? This is answered by looking at Table 16.5. This

TABLE 16.4

#### Components of Food

<i>Proteins</i>	<i>Carbohydrates</i>	<i>Fats</i>	<i>Vitamins</i>	<i>Minerals</i>	<i>Water</i>
For digestion, building body parts and growth, also energy	Main energy source	High energy source, for taste flavour	Essential for body reactions. Proper growth and health	Essential for body reactions. Proper growth and health	Essential for body reactions, digestion, transport, and waste removal

TABLE 16.5

#### Recommended Daily Needs of Some Food Constituents

	<i>Calories</i>	<i>Proteins</i>	<i>Fats</i>	<i>Minerals</i>	<i>Vitamins</i>
12-15 year old girl	2200	2.5 g	30	10	1 mg of A
12-15 year old boy	2600	per kg of body weight	to 50 g	to 30 mg	1 mg of B 50 mg C or more

Table tells us how many calories, proteins and other materials we need everyday for a healthy body.

For grownups, the amount of protein needed in the diet is 1 gram per kilogram of body weight. Children need twice as much since they are growing fast. Nursing mothers and pregnant women need more protein too, to cater to the needs of the growing baby.

This also means that just eating a lot of starchy food is not enough. Eating too much of fat does not help the baby grow well. The fat will simply stay stored and may even be harmful to the body. You will only be fat, not stronger! For being

healthy and strong, you must eat the right amount of food containing the right amount of each component. Such food is called *balanced* food. A meal in which you eat balanced food is called a *balanced* meal. A group of balanced meals taken during the day is called a *balanced* diet. Table 16.6 gives the balanced diet for a 12 year old child like you. A *balanced* diet has these important qualities.

1. It is rich in essential nutrients such as vitamins, minerals and certain amino acids.
2. It provides just enough raw material (not more nor less) to take care of the

TABLE 16.6

## A Balanced Diet for a 12 Year Old Child—for One Whole Day

Food stuffs	Vegetarian		Non-Vegetarian	
	Weight	Volume of Cooked Food	Weight	Volume of Cooked Food
Cereals	320 g	10 cups	320 g	10 cups
(a) rice	160 g	5 cups	110 g	5 cups
(b) wheat	160 g	6-7 chapatis	160 g	6-7 chapatis
Pulses (dal)	70 g	3 cups—thin after cooking	60 g	2 3/4 cups—thin after cooking
Green leafy vegetables	75 g	2 cups	100 g	2 cups
Other vegetables—roots and tubers	75 g	1/2 cup	75 g	1/2 cup
Fruit	50 g	1/2 fruit	50 g	1/2 fruit
Milk	250 g	1 glass	250 g	1 glass
Fat and Oil	35 g	2 tbsp.	35 g	2 tbsp.
Sugar or Jaggery (gur)	50 g	3 tbsp	35 g	3 tbsp.
Meat, fish or egg	—	—	30 g or 1 egg.	—

needs of growth, repair and replacement of cells, tissues and organs in the body.

3. It provides the energy required by the body.

#### ANSWER THESE

1. What is a balanced meal?
2. How many Calories does a 12 year old boy or girl need each day?
3. How can this boy or girl get this in the diet?
4. What are the three important qualities of a balanced diet?

#### 16.4 Value of Some Everyday Food Items and Food Fads

We use rice, wheat, bajra and similar cereals as staple food. These cereals give us sufficient energy if we eat the right amount. The *dal* and the meat give us the proteins. It is important, therefore, to eat enough of these. Vegetables are rich in vitamins and minerals as well. Green vegetables with fibres in them, such as spinach, cabbage, lady's finger (*bhindi*) and beans are important. The fibre in them helps in the movement of food through our system. The fibre content in foodstuff is also called *roughage*.

Take the green leafy vegetable called spinach. It comes in many varieties. The common one called *palak* in Hindi or *Mulakeerai* in Tamil, is a great health giver. 100 grams of spinach have 2 grams of proteins, 0.7 grams of fat, 1.7 grams of minerals, 3 milligrams of Vitamin A, 30 milligrams of Vitamin C,

0.6 grams of fibre or roughage, 2.9 grams carbohydrates and give us 26 calories. And it is inexpensive. Or take the banana fruit. When you peel its skin and eat one, you have taken in 1.1 grams of protein 0.1 gram of fat, 0.7 gram of minerals, 6 milligrams of Vitamin C, 0.03 milligram of Vitamin A, 25 grams of carbohydrates and 104 calories of energy.

Now, let us take grapes. It is an expensive fruit available only in season. 100 g of grapes give you 0.5 g of protein, 0.3 g fat, 0.6 g of minerals, no Vitamin A or B, 1 mg of Vitamin C, 2.9 gram of fibre and 17 calories of energy. Yet many people think grapes are more nutritious than bananas or spinach. Why? Just because it is expensive does not make it a better food. This idea that because something is costlier and harder to get should be more valuable as a food is called *food fad*. A fad is simply a peculiar idea, often a prejudice. There are many such food fads, which are incorrect. *Eating bhindi (lady's finger) makes you good in mathematics, or eat a lot of ghee to become healthy*. There is no scientific basis behind these statements.

How did such food fads come about? Firstly, lack of knowledge leads to wrong beliefs. Until 50 years ago, we did not know enough about the food value of many food items. Perhaps an excellent mathematician once liked to eat a lot of *bhindi*. People might have thought that maybe if they do the same, their mathematics might improve! This belief probably persisted. Secondly, people

were not used to newly introduced items. Even 30 years ago, a *dosai* was difficult to get in Srinagar or a *samosa* in Kanyakumari. Cauliflower was not native to India. It was brought from abroad. When it came to India, probably some people felt reluctant to eat it and invented reasons for not eating it! Many food fads are simply such inventions. Thirdly, custom and tradition give rise to fads in food and eating habits. And lastly, some people think that if a food item is expensive, it must be good for you. You just saw how the poor man's banana or spinach has more food value than the expensive grapes.

### Activity 6

Make a list of food fads. Also write down why each of them is a fad.

### ANSWER THESE

1. Which one offers you more energy—one banana or 100 grams of grapes?
2. Which has more vitamins—100 grams of spinach or 100 grams of grapes?
3. How did food fads start?

### YOU NOW KNOW

- The body is a living machine, but with some essential differences from non-living machines.
- For proper growth and maintenance, our bodies need adequate food.
- Food has many components.
- Carbohydrates are the main source of

### OUR RESPONSIBILITY

In our country, people do not have enough food to eat. Even if food is available, they do not have money to buy enough of it. That is why we have a large number of people suffering from diseases which are a result of their not eating enough. The country's food problem is becoming greater every year due to an increase in our population. Can we help solve this problem? Here are some ways in which we can help.

- (i) We should grow more food. To do this, we should work harder on our farms, and use better seeds and sufficient fertilizers.
- (ii) The food that we produce should not get spoilt or eaten away by pests. In our country, at present, a large amount of food is eaten away by rats, insects, birds, and stray cattle.
- (iii) The food grains that we grow should be inexpensive and of good nutritive value.
- (iv) Each one of us should make sure not to overeat or waste food.
- (v) We should try to change our food habits, so that (a) we all get enough of the right kind of food, and (b) we all use food that is easily and cheaply available in the region.
- (vi) We should do our best to see

that the population of the country does not increase.

#### WE ARE LUCKY!

If you observe carefully, you will find that animals other than man spend most of their working time searching for food. In the very early days, man also did the same. But today, he does many other things besides looking for food. This is because he has learnt to farm. A small number of people can today produce food for a large number of people. Many, therefore, have time to do other things.

energy in our diet.

- Proteins help in digestion of food, build body material, and in many body functions.
- Fats are largely stores of energy.
- Vitamins and minerals help proteins

in their functions. They also build body parts and keep organs healthy.

- Water is the essence of life.
- We should eat a balanced diet.
- A balanced diet for a 12 year old child means about 2500 calories, 2.5 grams of protein per kg body weight, 30-50 grams of fat, 10-30 milligrams of various vitamins daily.
- Expensive food is not always the best food.
- Food fads are just superstitions.

#### NOW ANSWER THESE

1. What are the five components of food?
2. What are the roles of each of these components?
3. What is hibernation?
4. How does the polar bear meet its energy needs during its long sleep in winter?
5. What is the best diet for a 12-year old child?

### Health and Diseases

WE HAVE LEARNT how a balanced diet helps in maintaining proper health, good growth and repairing and replacing worn out and damaged parts of the body. In this chapter we shall study about good health and how to maintain it. Your health is affected not only by an unbalanced food, but also by diseases caused by infection. Infection happens when germs enter your body. Diseases carrying germs are found in the environment around us. Therefore, when we want to be rid of disease, we can do two things. One is to take medicines to cure the infection in our bodies. The other is to keep the environment clean and *hygienic*. When we do that the germs will find it very difficult to exist there. And we will have removed, or reduced, the cause of many diseases.

#### 17.1 Good Health Needs the Right Type of Food

We have seen that a balanced diet is necessary for good health. This diet has carbohydrates, proteins, fats, vitamins and minerals in proper amounts. Each of these has a particular role. Not only should the meal be balanced, it should

also be sufficient for the needs of the body. Inadequate amount of food leads to insufficient nourishment. The condition arising out of this is called *malnutrition*. Thirty years ago, India did not produce enough cereals and malnutrition was a big national problem. With improved agricultural methods, our nation brought about what is called the *Green Revolution*. This meant using better rice and wheat seeds in farms, better irrigation methods, use of fertilizers and better storage of the harvested grains. With this revolution, we now produce about 150 million tons of rice and wheat every year. Each of us has about 200 kg of food per head every year. As a result, malnutrition among Indians has reduced considerably. Yet we are a very large population of about 750 million people. And there are, unfortunately, still many people who suffer from malnutrition. Most of them are poor and cannot afford to buy adequate food. They are lean and weak and do not have enough strength and stamina.

A major task and effort in the country today is to abolish malnutrition.

#### ANSWER THESE

1. What is malnutrition?

2. What is the population of India now?
3. What has led to the Green Revolution?

### 17.2 Deficiency of Carbohydrates

We learnt that a seventh class student like you needs about 2200-2500 calories daily. Much of these calories come from the carbohydrates that you eat. For this need, you should eat about 320 grams of cereals per day.

Other cereals, besides rice and wheat, also contain much carbohydrates. Some of these are pearl millet, finger millet and maize. In Table 17.1, we give the names of these in some Indian languages.

Many families in the villages and even cities often eat these cereals in their meals. This is excellent practice because these cereals have as much carbohydrates as rice or wheat. They also have more proteins, minerals and fibres in them than rice has. They also provide variety in the food that we eat.

Whatever your meal preferences be, you must eat enough carbohydrates to give you adequate calories. A diet that has less than 2200 calories per day is *deficient* in carbohydrates. Such deficient diets will lead to weakness in the body and loss of stamina. On the other hand, do not overeat either. Too much of starch does not build strength. It only leads to laziness and lethargy.

### PROTEINS AND FATS ARE NEEDED TOO

We know that proteins are very important since they help in digestion, in building body parts and for the necessary functions of the organs. A diet that does not have enough of proteins would lead to malnutrition. Similarly, fats are reserve food sources and our diet should have a small amount of fats in it. Table 5 of chapter 16 shows how much proteins and fats you should eat in your daily diet.

### VITAMIN DEFICIENCY

Vitamins are needed only in small quantities in the daily diet. But they are

TABLE 17.1

Names of Some Cereals in Indian Languages

Cereal	Hindi	Tamil	Telugu	Marathi	Gujarati	Bengali
Pearl millet	Bajra	Kambu	Gantelu	Bajri	Bajri	Bajra
Finger millet	Ragi, Mundal	Ragi	Ragulu, Chollu	Nachni	Ragi, Bhav	
Maize	Makka	Makka-cholam	Makka-jonnaalu	Muka	Makai	Bhutta
Sorghum	Juar	Cholam	Jonnaalu	Jwari	Juar	Juar

essential for two reasons. One is that many of them are not synthesized in the human body. They have to be taken in the diet. The other reason is their function. Many of the vitamins act as helpers for enzymes to do their tasks. Some of them react in the body to produce essential substances. They thus regulate body activities. For this reason, vitamins are called *essential nutrients*.

There are many vitamins and they

are simply named by the letters of the alphabet. Vitamins A, B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, B<sub>12</sub>, C, D and K are some examples. Each one is needed for a specific purpose. If you do not get the proper kinds and amounts of vitamins in your diet, you develop diseases. These are called vitamin deficiency diseases that affect the eyes, skin, bones, hair and the general growth. In Table 17.2, we list a few of the vitamins and their importance. We also

TABLE 17.2

## Importance of Some Vitamins in Your Diet

Vita- min	Importance	Where it is found	Deficiency Diseases
A	Helps keep eyes, hair and skin healthy	In spinach, carrots, butter, sweet potatoes, mangoes	Poor vision, bad eyes, night blindness
B <sub>1</sub>	Helps the digestive and nervous system work well	In eggs, meat, whole cereals, yeast.	Disease called <i>Beri-Beri</i> Extreme weakness
B <sub>2</sub>	Keeps the skin and the mouth healthy	In green leafy vegetables, peas, beans, milk	Retarded growth Bad skin
B <sub>12</sub>	Needed for healthy blood, and for proper growth of the body	Mostly in meat and non-vegetarian food	Anaemia—deficiency of red blood cells or haemoglobin
C	Helps resist infections, helps keep teeth, gums and joints healthy	In almost all fresh fruits, specially lime, lemon, oranges and gooseberries guava	Disease called <i>scurvy</i> —swollen gums, livid spots, loose teeth and joints
D	Aids in the normal growth of bones in the young	In fish liver oils, milk. Body exposed to sunlight produces a little bit of vitamin D	Disease called <i>rickets</i> —soft bones, spine, and bow legs
K	Helps in the clotting of blood	In green leafy vegetables, tomatoes, egg yolks	Excessive bleeding after injury

describe some deficiency diseases.

You saw in the last chapter some pictures of animals that had vitamin deficiency. When the necessary vitamin was given to them in their feed, they grew healthy again. In figure 17.1, we show a chick that did not have enough vitamin  $B_{12}$  in its diet. It became a healthy bird within three weeks of feeding small amounts of this vitamin. Thus, vitamin deficiency diseases can be easily cured. You know the proverb, *prevention is better than cure*. Is it not better for us to eat vegetables, fruits and milk that are already rich in vitamins? Then the doctor does not have to ask us to eat vitamin tablets later.

#### IMPORTANCE OF MINERALS

All the chemicals we have described so far are carbon-based and found in living organisms. These are called organic

compounds. Living beings also need other molecules made from elements besides carbon. Common salt or sodium chloride is one such example. Such compounds that are not carbon-based are called inorganic compounds. Since many of these are found in soils, grounds and the earth, they are called minerals. Our body needs many such mineral substances for its proper function.

Our bones and teeth are largely made of calcium salts. Without calcium, our heart will not beat properly, blood will not clot and muscles will not work well. Children need more calcium than adults since they are growing. Calcium is thus an essential mineral.

Where is calcium found in our diet? In milk and buttermilk, in ragi, tapioca and in green leafy vegetables. Rice and wheat have very little of calcium.

Another important mineral is pho-

Fig. 17.1 Vitamin  $B_{12}$  is necessary for proper growth. Feeding a diet containing this vitamin restored good health to this chick.



sphorus. In fact, the energy in the body is handled in the form of phosphates. These are called the energy currency of

cells, just as the rupee of our country or the Taka of Bangladesh. Also, bones and teeth are made of the compound calcium

TABLE 17.3

## Some Minerals in our Diet

<i>Mineral</i>	<i>What It Does</i>	<i>Its Sources</i>	<i>What Happens when it is Deficient</i>
Calcium	Builds bones and teeth. Regulates heart and muscles. Helps blood to clot	Milk, butter-milk, tapioca, green leafy vegetables	Brittle bones. Improper heart beat. Bad muscle movement. Excessive bleeding
Phosphorus	Energy currency of our cells. Builds bones and teeth	Cereals, pulses (dal), milk	Body weakness. Bad teeth and bones
Iron	Helps blood transport oxygen to cells and remove carbon-dioxide. Pregnant women need more than usual	Cereals, pulses, meat, green leafy vegetables, vegetables, zira, Heeng	Anaemia
Magnesium	Regulates muscles and nerves. Helps some enzymes	Green leaves, cereals	Muscle and nerves become weak in action
Sulphur	Formation of proteins	Cereals, pulses, Methi, Kala Namak	-do-
Copper Cobalt Zinc	Formation of proteins, enzymes, vitamins	Cereals, pulses, vegetables, meat	Lack of appetite, retarded growth, anaemia
Iodine	Regulation of the oxidation of food	Fish, salt from the sea	Disease, called <i>Goutre</i> , abnormal growth and thyroid gland, abnormal metabolism
Chlorine	Enzyme activities, nerve functions, stomach action	Salt, cereals, fruits	Dehydration, Extreme weakness
Sodium and Potassium	Keep all body fluids and cells in proper order	Salt, most foods	-do-

phosphate. We need at least one gram of phosphorus in our daily diet.

Cereals and pulses (*dal*) are rich in phosphorus. Milk is also good since it has both calcium and phosphorus in it.

Table 17.3 lists the minerals needed in our diet as essential nutrients. It also shows their functions, where they are found and what happens when each of them is deficient in the diet.

Tables 17.2 and 17.3 look like a stock register from a chemical stores. But the amounts of these essential nutrients that we need are quite small. Fortunately, they are available adequately in a well balanced diet as the one described in the last chapter. You are wise if you make this effort and eat properly. Not doing so leads to deficiency diseases.

#### ANSWER THESE

1. Make a detailed list of what you eat daily.
2. What are the cereals, vegetables, proteins and fat sources you eat in this diet?
3. How can you vary this diet without making it costlier?

### 17.3 Preparation of Food

Most of foods need to be cooked to make them fit for eating. This makes it easier for digestion and also tastier. Cooking means heating the item, usually after adding something like salt, oil, spices or water. Addition of spices, salt, vinegar, oil or butter and other ingredients makes the cooked dish tasty. The art of cooking

is largely based on what to add and how to produce the tasty dish. There are over 50 dishes that are cooked in India, using rice alone! Plain rice, lemon rice, *kichri*, *Pongal*, *Kheer* or *Payasam*, *Biryani*, *dosa*.... you can add many more! All use rice, but each one is prepared differently and with different additions.

#### BACTERIA SPOIL FOOD

Unfortunately, food, raw or cooked, gets spoiled easily. Leave a slice of bread, a *samosa* or milk out in the open for a day or two and you see that they are spoilt. Spoilage happens because of the action of bacteria or germs on the food. Uncooked or raw food like rice, wheat and pulses also get attacked by insects, rats, fungi and bacteria. All these make the food poisonous, contaminated and harmful to health.

*How can we prevent food from spoiling and contamination?*

1. Cleaning of rice, wheat and pulse grains and storing them properly is essential. Before cooking, they are to be washed thoroughly with water. This is what happens in your kitchen everyday. This prevents and reduces contamination.
2. Food kept in closed containers will last longer. Why? Germs and insects present in the surroundings will not be able to contaminate this food.
3. Heating kills many germs. We heat milk to prevent it from spoiling. Many food items can be preserved simply by drying them in the sun.

- This makes them less damp and safer from contamination. Bacteria do not grow well in dry conditions.
4. Bacteria do not grow and multiply in the cold. This is why food kept in ice-boxes or refrigerators lasts longer. The scientist Louis Pasteur of France came out with an excellent method to preserve food. This method, called *pasteurisation*, is used in milk dairies. First the milk is heated to kill most of the bacteria. Next it is cooled very fast to prevent the remaining bacteria from growing. And the milk is stored in the cold. This is why the dairy milk that we buy comes cold. Fish and meat are transported to far off places in special cold containers. Food can be frozen and kept fresh for months. When needed, it can be warmed up again and eaten. This frozen and rewarmed food is just as nutritious as fresh food.
  5. Some items of food that are easily spoiled can be preserved differently. Fruits and vegetables are made into jams, jellies and pickles. The salt and the spices in the pickles or the sugar in the jam prevents the bacteria from spoiling the items. Potatoes, bananas, tapioca and pulses are cooked and prepared as wafers or *papad*. These can be stored properly and used later.
  6. Sometimes, special chemicals are added to food items as preservatives. Sodium metabisulphite is added to jams, juices and jellies to keep them from spoiling.

## ANSWER THESE

1. List all the uncooked items of food that you can see around you. Indicate the importance of each of these in our diet. How are these items to be protected from spoiling or contamination?
2. Prepare a list of the various methods of storing and preserving mango, guava, milk, fish and potato.
3. Sometimes we purposely 'spoil' food items to convert them into other food items. Some special 'good' bacteria do this spoiling. Think about this and write down at least three examples.

In the last question, we had mentioned about some *good* bacteria that convert some food items to some other edible ones. These are exceptions. But, largely, food spoiled by bacteria is not good for health. Such spoiled food only brings harm to our health.

## CONTAMINATION OF WATER

Look at the pond in Figure 17.2. This pond is the main supply of water in this area. If you live in this area, will you drink this water? Will you use it at home for cooking? Is it safe or harmful for your health? Remember you have no other place to go to get water. So you have to use only this water. If it is not safe, why is it not safe? What will you do to make it safe for using?

This is the problem in many places in India, particularly in villages. In cities, people use the water that comes from



Fig. 17.2 A Pond being Used for Many Purposes

the taps. Even there is the problem of water supply in slums. So what should one do?

What makes the water unsafe for use? There are several undesirable substances in it; these are called *contaminants* that produce harm. Dirt, wastes from washing clothes, bathing animals and humans, and sewage are some sources of contaminants. Bacteria grow abundantly in such water. Many of these are extremely dangerous when they infect us. The most dangerous of these is a germ that causes the disease *typhoid*.

In order to make the water safe for use, first we can decant the water and filter it. This removes the suspended impurities. The undesirable impurities that are dissolved in it should be removed. This can be done by distilling the water or running it through special materials. Now we have to remove the harmful bacteria. This is done by treating the water with the gas chlorine or with bleaching powder. Bleaching powder releases chlorine. This is what the municipal water works people do, and this chlorination is what often gives the tap water a particular smell and taste.

At home, we can filter the water, boil it well, cool it and add a very small amount of either bleaching powder or potassium permanganate to it. This treated water is largely free of bacteria and is safe. The water should be stored in a container with a lid or a cover. Earthen pots are excellent for this purpose, since they also keep the water cool. These days, one can buy water filters which, though expensive, are good.

### BACTERIA IN THE ENVIRONMENT

Insects like flies carry germs in their hair and legs. The fly feeds and multiplies in insanitary places. See Figure 17.3 for a picture of the fly and how it can carry germs from place to place.

When flies sit on our food, they drop off millions of bacteria there. Many of these cause dangerous diseases like cholera, tuberculosis, typhoid and diarrhoea. Flies are responsible for causing about twenty different diseases in human-beings and animals.

#### Activity 1

A glass or transparent plastic vessel called the petri dish is useful for this experiment. You would also need the substance called agar that sets into a gel in water. Ask your teacher how to prepare a petri dish with agar gel in it. It is done by taking a hot solution of agar in water and pouring it in the dish. Upon cooling it sets into the agar gel. Catch a live fly and slip it under the cover of the dish. Let it walk around the agar for a few

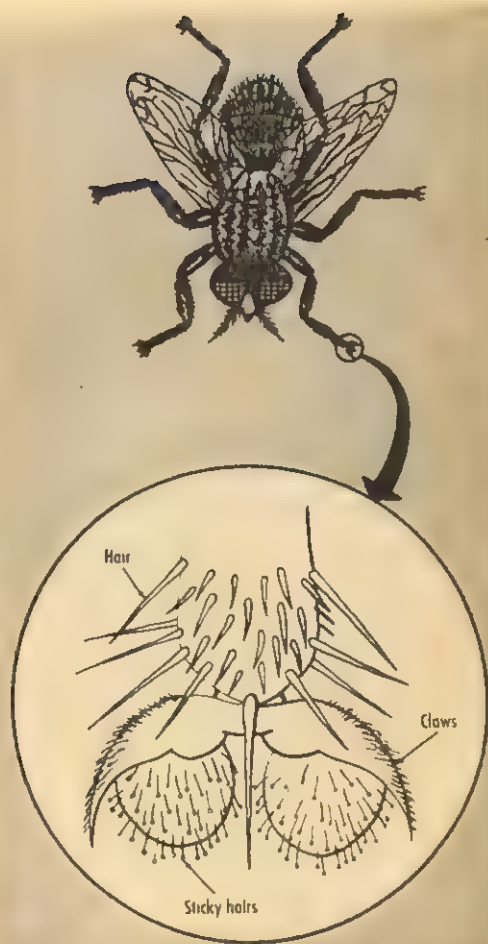


Fig. 17.3 The limbs of the fly contain sticky hair which can carry and transport bacteria from place to place.

minutes. Remove the cover and let the fly fly out, and cover the dish again.

Leave the dish in a warm dark place for a few days. What do you now see on the agar? Where did these micro-organisms come from? You did not even need a powerful microscope to see these. What does this show you about the way

flies can carry diseases?

There are other insects that carry diseases too. The mosquito is one such. Malaria is a disease caused by a microbe called *Plasmodium*. The mosquito is the carrier of this microbe. When a mosquito bites you, it injects the *Plasmodium* into your blood. The microbe lives off the blood and multiplies. Since it lives solely on your blood as its food material, it is called a *parasite*.

To fight these diseases, we can do two things. One is to kill the microbe itself that causes the disease. For this, we take medicines against cholera, tuberculosis, malaria and other such diseases or we get vaccinated. The other way is to kill the carriers like the fly or the mosquito. Insecticides are substances that act against these carriers. A common method is to spray the rooms in the house with these substances.

The best way to proper health of the whole community is through cleanliness. If we do not let garbage and sewage collect and stagnate, many microbes will not be able to grow and multiply. Flies will be reduced in number and fly-borne diseases will decrease. The sanitation of a place directly reflects the community health. Contamination of water, ground and air will be reduced. All this needs only a little effort on our part.

We wash and bathe daily and wear clean clothes. We are proud of our personal cleanliness. But just look around the roads and the neighbourhood. Is it clean? Is it enough to be personally

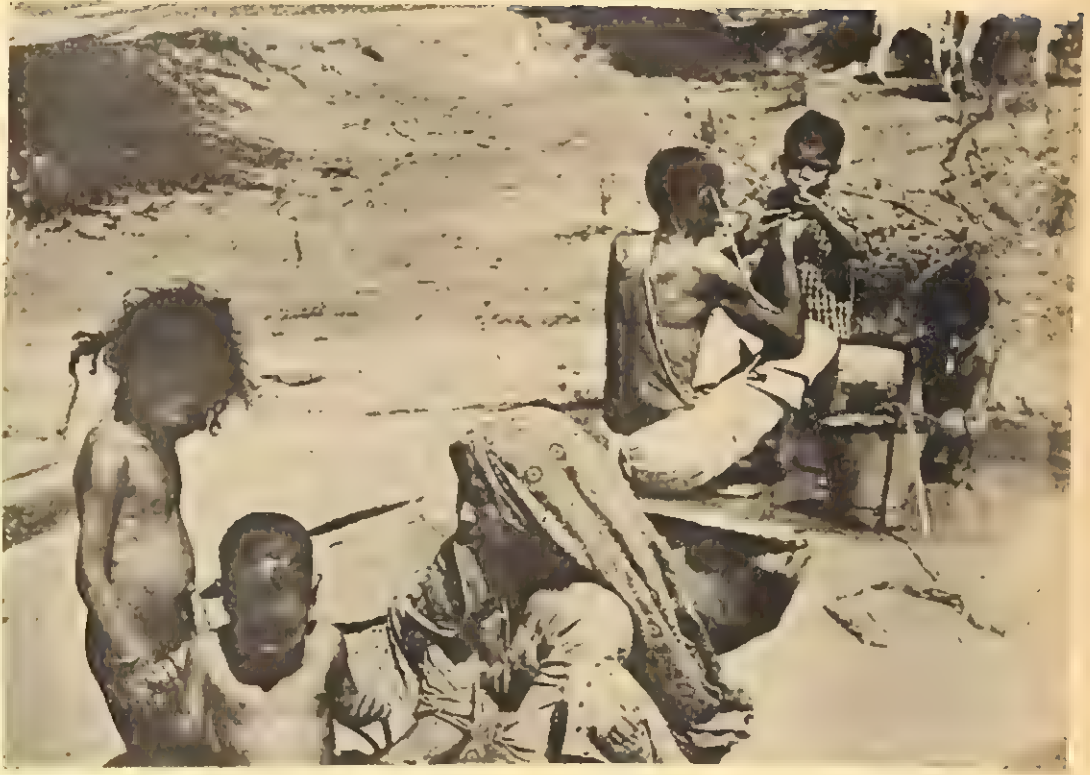
clean? Of course, if we do not practise personal hygiene, we will fall sick. Should we not keep our houses, colonies, streets and towns also clean? Microbes need insanitary places to breed. They are transmitted through water, garbage, air and exposed to spoilt food. Let us try and stop them from breeding. An easy way is to keep our environment clean.

#### ANSWER THESE

1. What makes water unsafe for use?
2. How would you make water safe for use at home?
3. Name a few insects and germs that contaminate water and food.

#### YOU NOW KNOW

- Insufficient nourishment leads to malnutrition.
- Carbohydrates give us energy. Deficiency of carbohydrates in our diet leads to weakness and loss of stamina.
- Too much of carbohydrates in the diet is also bad. It does not build more strength, but only laziness.
- Proteins are needed for body functions and body-building.
- Vitamins and minerals are essential nutrients. Lack of vitamins leads to specific illnesses. These diseases can be prevented by taking vitamins and minerals in the diet or as tablets.
- Bacteria spoil food.
- Water gets polluted easily. Special methods can be used to purify water.



*Fig. 17.4 Misuse of a Village Well. How can this be avoided?*

**NOW ANSWER THESE**

1. Look at Figure 17.4 which shows some people around a village well. Is the well being used properly? What improvement can you suggest?
2. Name some items of food that are rich in calcium.
3. How much protein do you need in your daily diet?

## CHAPTER EIGHTEEN

### Soil

WE OFTEN have to remove dust from our books, floors and furniture. Sweepers clean the streets of our cities, towns and villages. Have you wondered where the dust comes from or what happens to it after we have swept it away?

On summer afternoons you must have seen the hot air rise carrying with it loose, dry particles of earth. Stormy winds do this more vigorously. Even still air has extremely fine solid particles suspended in it. You can easily see them in a light beam that enters a dark room. It is these particles which settle on our books, floors and streets as dust.

In this chapter we shall study about soil, which is the substance which makes up the surface of the earth. We shall study what it is made of, and how it has been formed. We shall also study the methods of conserving this very important part of the earth.

#### 18.1 Contents and Types of Soil

Soil is an important part of land. Soil provides the bed for plants to grow. Without soil there would be no grass, no crop, no trees, and no nourishment for us or other land animals.

You might think that most of the land on earth is covered by soil. This is not true. In fact many parts of the surface of the earth have no soil at all. Large areas of the Arctic and Antarctic continents are covered by ice and snow, not soil. The snow-covered areas of high parts of the plains have no soil. Ice, snow and rocks form one-fifth of the total land area of the earth. We usually see the surface of the soil. If we look at the sides of a ditch or a trench we can see what is under the surface. Such a view of soil is called the soil profile. It enables us to get an inner view of the soil.

Look for a place where the foundation for a building or a well is being dug. The sides of a road on a hill or steep river banks also offer such a view.

#### Activity 1

- Make a trench by digging the soil with a spade, or visit a spot where such a digging is in progress. Observe the soil from the sides. Do you see layers? How many?
- Observe these layers with a magnifying lens. See if there are any living organisms or the body parts of a dead organism.

- c. Scratch or scoop some soil from each layer and feel its texture.
- d. Scoop out a little soil from each layer. Run some of it between your thumb and finger. Is it smooth or is it coarse in texture?
- e. Pour a little water on each layer. Does the water run off the sides, or does the water get soaked?
- f. Collect some samples of soil from each layer in plastic bags. Record the colour, texture and dampness of each layer. Keep the samples for further activities below.

You will find that soil is arranged in two or more layers. The uppermost layer is usually the darkest in colour. It is called the *A-horizon*. It contains a lot of decayed plants and animal remains. These are called *humus*. It is also the home of worms and insects. You will also find the roots of plants, algae and fungi. The humus makes the soil very fertile. This layer is also soft, porous and can hold more water. It is also called the *top soil*. It is this top soil from which plants get the essential nutrients.

The next layer is usually harder and more compact than the top soil. It is called the *B-horizon*. It has very little of the organic matter found in the upper layer. This layer is, however, rich in soluble minerals and iron oxides.

The lowest layer is the *C-horizon*. It is made of small lumps of rocks with cracks and crevices. It would be difficult to dig beyond this layer with only a

spade. Beneath the C-horizon, we reach what is called bed-rock.

### Activity 2

- a. Take a portion of the sample of top soil. Weigh this portion and record its weight. Keep the remaining top soil in the plastic bag and shut it tightly.
- b. Take the weighed portion and heat it for some time. You can even spread the soil on a piece of paper and dry it in the sun for about 2 days. Weigh the dry soil again. Do you find any difference in weight from the previously recorded weight? Why is it different?
- c. If you observe the sides of the closed plastic bag, you will see many droplets of water. What does this tell you?

As you move about, you may find soil of different colour, texture and dampness. Let us see the different properties that distinguish one soil from the other.

### Activity 3

- a. Collect soil samples from a lawn or a garden, from a river bed, from waste forest land or a jungle. You might not get all of these but collect as many as you can.
- b. Take the same amount of each sample and examine each of them the same way as in Activity 2. Note colour, water content and texture.
- c. Dry the samples and separate the big

gravel by hand. Grind the lumps if there are any.

- d. Sieve the soil samples with a coarse sieve. Keep the coarse and the fine particles separately.
- e. Sieve the fine soil again with a finer mesh or a cloth.
- f. Measure each component—gravel, coarse particles, fine particles and so on in each sample. Record your observation in the following table.

Location	Colour	Texture	Water Content	Amount of Fine Particles	Amount of Sand	Amount of Gravel	Classification
Lawn							
River bed							
Waste land							
Forest land							
Farm							
Play-ground							

You will find that the soil in different places varies in colour, texture, water content and particle size.

The colour of the soil can tell you the chemicals it contains. For example, reddish colour is due to the presence of oxides of iron. Black colour soil mainly contains dead organic matter and water.

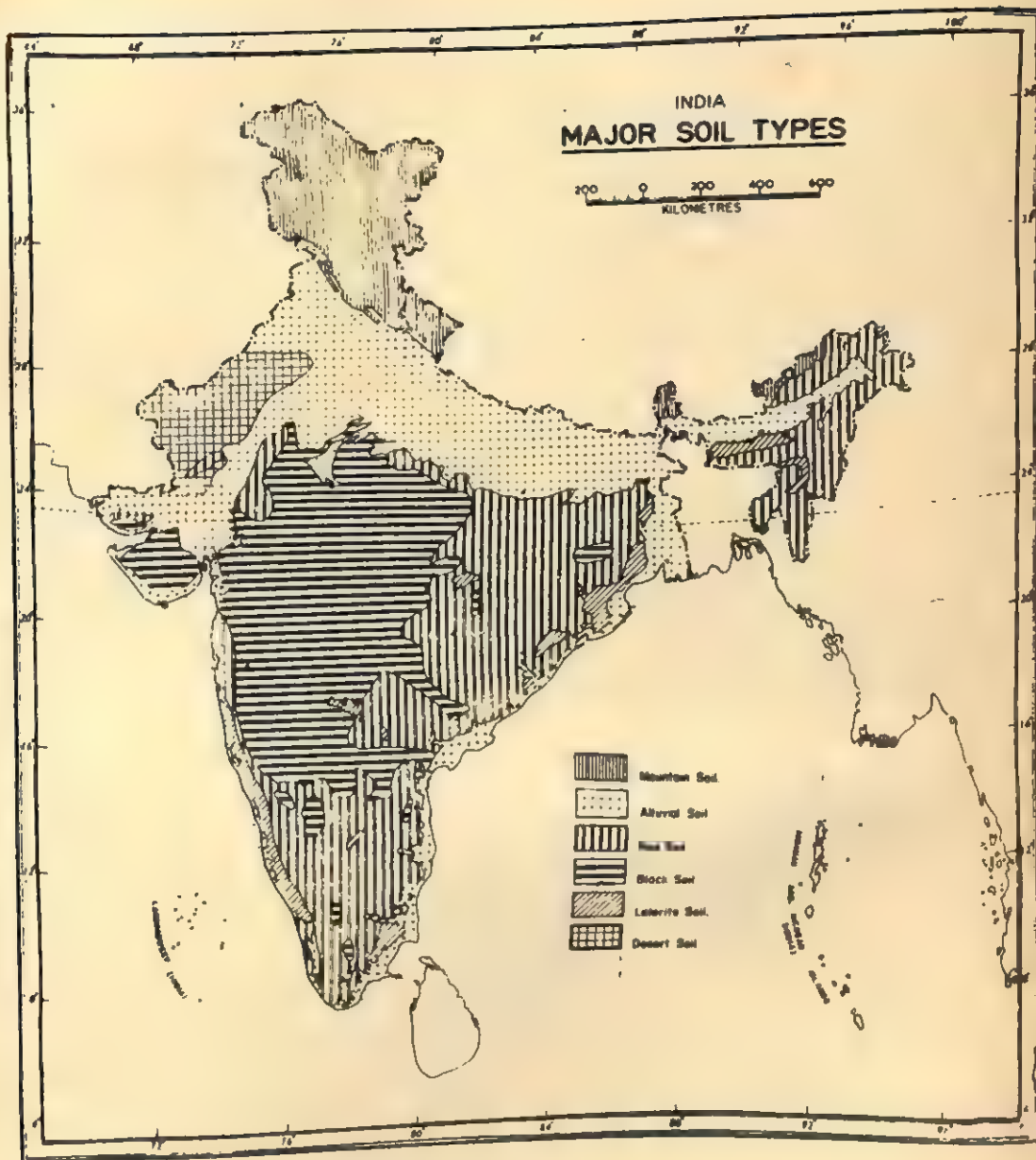
Various types of soil retain water in different degrees. Some types of soil allow water to drain through them. Some hold water for long time. If the soil can hold water, we say that it is *porous*.

Depending on the geographic region, the type of soil will vary in its colour, texture and contents. Some soils are reddish-brown in colour, some black,

some are sandy, and some mountainous and rocky. Figure 18.1 shows the Indian subcontinent classified in terms of the types of soil. The interior regions of Kerala and that of Tamil Nadu, southern Karnataka, Andhra Pradesh, Orissa and eastern Madhya Pradesh are rich in a type of soil, called the *red latosol*. The red colour is due to iron oxide present in the soil. This forms the top soil together with quartz and clay minerals. These

soils are poor in humus but become quite fertile when manure or fertilizers are added. In places where the iron oxide contents are low, the soil is rich in aluminium oxide.

The *black soil* area covers a large portion including Maharashtra and parts of Andhra Pradesh, Madhya Pradesh and Gujarat. It is as porous as the red soil is, and is particularly suited for growing cotton and sugarcane. The soil is rich in iron and magnesium, derived from rocks that are called *basaltic*. Moving a little further north towards eastern Rajasthan, Madhya Pradesh and southern Haryana and southwest Uttar Pradesh, the black soil region continues but with a greater



The territorial waters of India extend in the sea to a distance of twelve nautical miles measured from the appropriate base line.

**Fig. 18.1** *The major soil types in India. Can you see any relation between the major physical divisions and the different soil distributions?*

clay content and richer top soil.

The plains of Haryana, Uttar Pradesh, Bihar, Bengal and coastal Orissa and Andhra Pradesh are *alluvial* in soil content. Alluvial soils are transported by rivers for long distances. They are taken from their parent rocks and deposited in low lands. This soil contains gravel, sand and clay and is fertile.

The *desert soil* is coarse in texture because the fine layer on top has been removed by wind. Sandy and porous, the desert soil contains good amounts of soluble salts. Desert soil can support rich crops if it is irrigated. This point has been proved by the Indira Gandhi Canal of Rajasthan. Parts of Gujarat and Rajasthan in the west and Ladakh region in the northern part of the subcontinent are regions where the desert soil is found.

*Mountain soils* are found in the Himalayan region and the north-eastern parts of India. They vary in their contents from place to place but are highly fertile. They also have the highest humus content of all soils in India. Besides these types, the *laterite* type of soil is seen in the western ghats and parts of Tamil Nadu, Andhra Pradesh, Orissa and Assam. It is typical of the rainy climate. It is poor but supports pastures and shrub forests.

#### ANSWER THESE

1. Figure 18.2 shows the types of soil in the African continent. Which areas

of Africa would be desert, which basaltic, and which latosol? Compare them to regions in India. Use an atlas to name the regions and countries.

2. You see smooth and round pebbles at many places. Can you tell whether they have been shaped at those very places themselves, or transported from elsewhere?
3. What special form would a soil have if it has been transported by wind?

### 18.2 How Soil is Formed

We can guess the process by which soil must have been formed by studying the various layers of soil; their physical and chemical compositions. Each layer has its own history. The story of its formation is as interesting as the evolution of organisms which live on the soil.

If you dig into the ground you will soon come to a hard surface of rocks. This is the earth's crust and we shall begin the story of the soil from this surface.

Long long time ago, the surface of earth was very hard and rocky. As time progressed these rocks were broken into smaller pieces by violent earthquakes. Volcanic eruptions threw out pieces of molten rock from the interior of the earth. These molten rock pieces, called lava, deposited them at far away places. In fact, the shapes and sizes of rocks tell us a lot about the way they were transported.

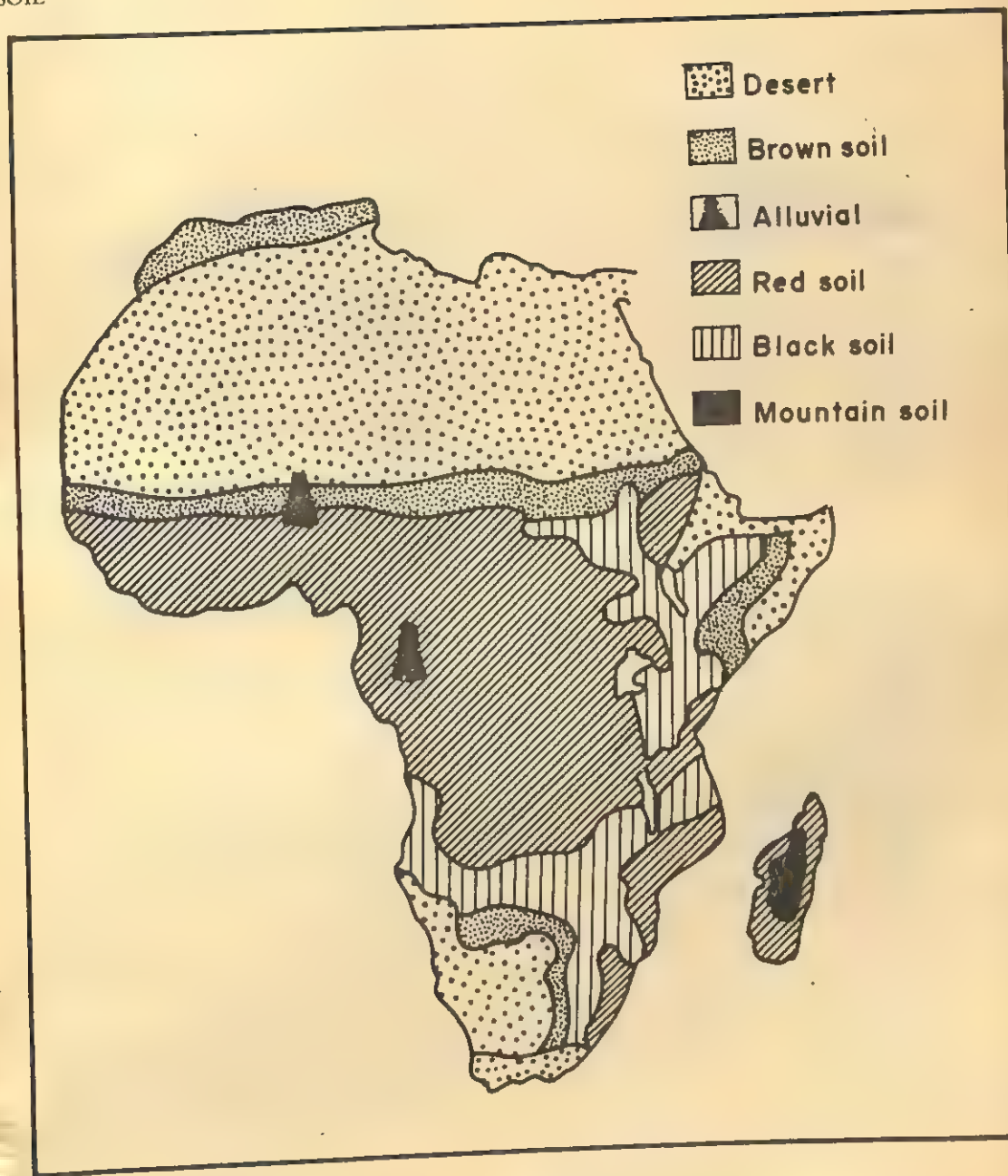


Fig. 18.2 Soil belts of the African continent

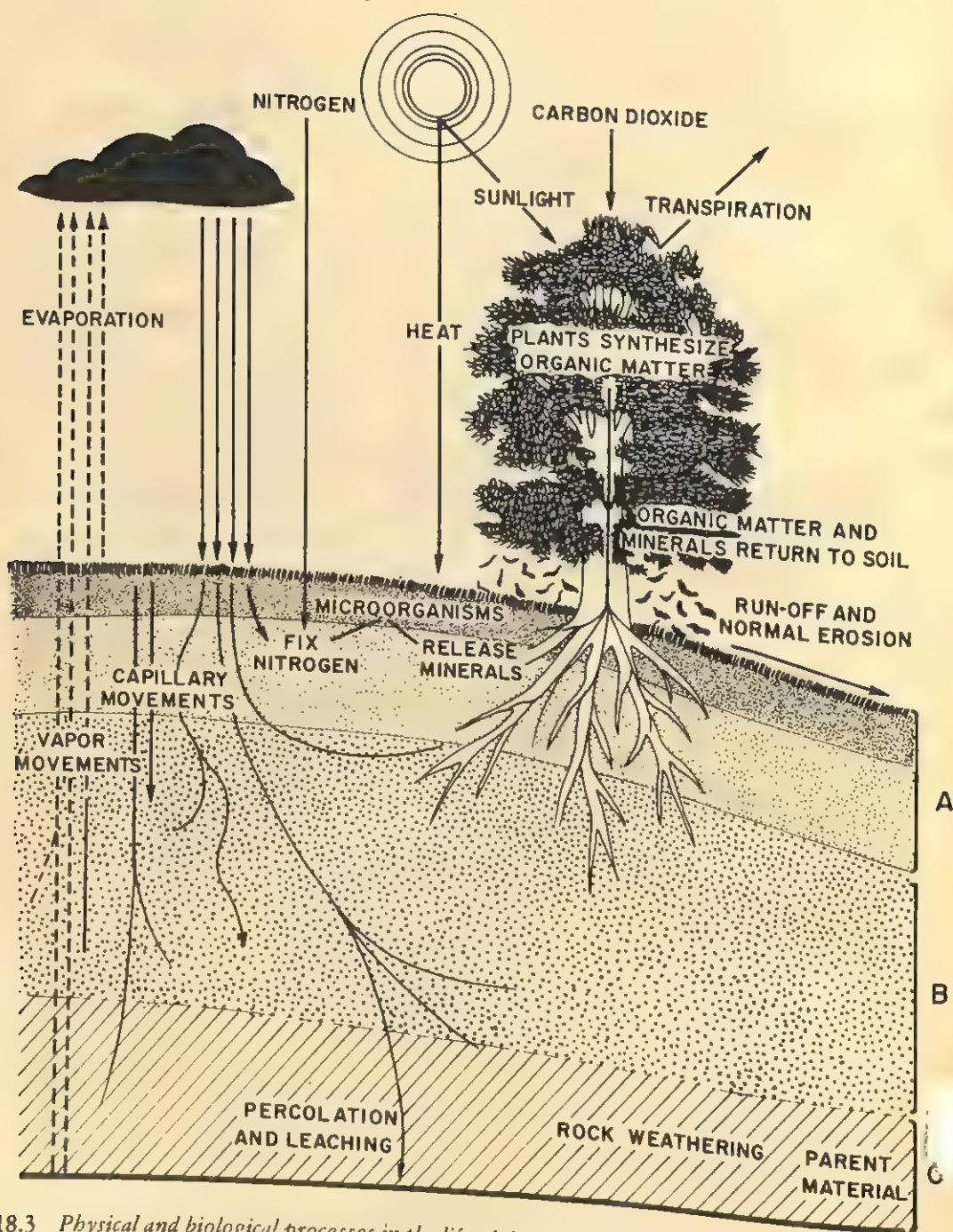


Fig. 18.3 Physical and biological processes in the life of the soil. Notice horizons A, B and C and the bedrock beneath.

Water also plays an important role in breaking huge pieces of rock into smaller pieces. Water enters the cracks and crevices of the parent rock. In winter, this water freezes to ice. Remember the unusual property of water—solid water—ice is less dense than liquid water. When the ice in the crevices of rocks expands, it cracks the rocks open and breaks them into smaller pieces. Rain and river water further break these pieces down to fine grains.

These actions of water, ice and wind, which break huge pieces of rock into finer particles, are called *weathering*. It takes thousands of years to weather rocks into the fine grain particles that make the soil. It is in these soils that microbes, algae, insects and worms grow and die. Roots of plants which enter the crevices of rocks also weather the rocks into soil. Clay and granular soil is formed in this manner. Figure 18.3 shows the physical and biological processes in the life of the soil. Plants remove water and various nutrients from the soil. Later the various plant parts return to the soil. There they decompose and release nutrients for a new cycle of plant life. You will now appreciate the saying—*of dust does life come and to dust does it return*.

### 18.3 Soil as a Resource

Have you seen how the season's first rains cover the earth with greenery? This would not happen if there was no soil. Throughout the summer, soil

provided the resting place to seeds and roots of dried plants. Rain water turns the soil into a vigorous field of physical and biological activity. The cycle we saw in Figure 18.3 is set into operation. Soil thus is a vital support to the system to the living world. Most of our primary food resources are grown here besides the timber needed for buildings, fuel and paper. We also use soil as raw material for making brick and mortar, pottery and other materials. Clay is even today an important resource used in making pots and crockery, and in building huts and sheds.

Soils also allow water from the surface—rains, streams and rivers—to slowly trickle through (*percolate*) their porous bodies and form the water table beneath. We pump this water out for our use during the dry season. Without the soil, all surface water would run off to the sea. It would not wet the earth below and be absorbed, percolated and stored underground.

In hilly regions, in particular, soils absorb and soften the effects of heavy rains and of the long dry spells in between. They absorb substantial amounts of the rain-fall and reduce the fury of flash floods. They also provide water continually in the dry season to keep alive plants and animals.

Do you now appreciate the critical importance of soil in sustaining life on earth? It thus becomes essential for us not to spoil or lose it but to conserve it. Soil is often carried away by strong winds,

or washed away by rains and rivers. Such removal of soil is called *erosion*, and happens in places where it is not covered. It is plants and shrubs—vegetation—that provide the cover and reduce the erosion of soil. You can appreciate this easily with these activities below.

#### Activity 4

In one tray, take a heap of loose soil with no grass vegetation. In another, take an equal amount of soil taken from a green lawn. Blow strong air with a fan on the two heaps. Which one loses more soil by blowing?

#### Activity 5

Fill a tray with loose soil. Fill another with soil taken from a green lawn. Soak both of them with equal amounts of water. Drain each of them from the edge. Which tray loses more soil in the wash?

These activities will show that soil which is not covered by vegetation is eroded rapidly. The root system of the vegetation binds the soil together and prevents erosion. Left to itself, nature achieves a balance between the erosion and the natural growth of the soil zone. But many activities of man are increasing soil erosion. What are these?

- A large number of trees are cut down for timber and fire-wood. This loosens up the soil and erodes it.
- Forests are uprooted to make farm land. This is particularly

dangerous in hilly areas. The tree cover on the hills softens rain effects, stops flash floods and stops landslides.

- Extensive ploughing and tilling of fields in order to feed a growing population.

You can add some more to this list. Each one of these activities upsets the natural balance and hastens soil erosion.

What are the methods to stop soil erosion? Quite simply, these should be ones that increase vegetation. Greater areas should be brought under cultivation. Hardy plants that survive in dry and hot climates should be planted in desert zones. When trees have to be cut, they must be replaced. All efforts must be made to cover about one-fourth of the total land area with trees and plants.

#### ANSWER THESE

1. What is meant by the term 'weathering'?
2. Name five uses of soil in human activities.
3. Why is soil not covered by vegetation easily eroded?

#### YOU NOW KNOW

- Soil is arranged in three layers above bedrock.
- Humus is decayed organic matter found in the topmost layer and is the source of nutrition for plants.
- Soils from different regions are different in properties.

- Red latosol, black soil, basaltic, alluvial, desert soil and mountain soil are found in India.
- Soil is formed from rocks by the weathering action of earthquakes, volcanic lavas, water, ice and wind.
- Soil is an important natural resource.
- Soil erosion occurs easily when the soil is not covered by vegetation.
- Soil erosion leads to famines and deserts, but can be stopped and reversed by increased vegetation.

## NOW ANSWER THESE

1. What are the basic types of soils?
2. Which soil will have the highest humus content and which the least?
3. Parts of Maharashtra, Andhra Pradesh, Madhya Pradesh and Gujarat are particularly known for their sugarcane and cotton production. What kind of soil would be the best for these crops?
4. How does the unusual density of ice help in the formation of soil?
5. What are the causes of soil erosion? And what are its effects?
6. How can soil erosion be prevented?





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